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COLORADO
AIR QUALITY DATA REPORT
1984

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Department of Health
Air Pollution Control Division
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COLORADO

AIR QUALITY DATA REPORT



1984

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1. INTRODUCTION

1.1 Purpose and Overview

The purpose of this report is to present the air quality monitoring data generated by the Colorado Air Pollution Control Division in 1984, and to provide a historical perspective from which the significance of that data can be interpreted. Air quality monitoring measures the concentrations of various pollutants (undesirable gases and particles) in the air. The monitoring is designed to address Federal and State requirements to determine pollutant concentrations related both to National Ambient Air Quality Standards (NAAQS) and pollutants for which standards may be anticipated. Primary standards are intended to protect public health. Secondary standards are intended to protect public welfare. The current NAAQS are presented in Table 1-1. Pollutant concentrations that are higher than the standards are considered unhealthy. Concentrations below the standards are considered acceptable.

1.2 Monitoring Sites

Air quality data are developed using two basic methods: the continuous monitoring of gaseous pollutants and the Hi-Volume sampling of particulate pollutants.

The State of Colorado operated 15 continuous gaseous monitoring stations in 1984. Carbon monoxide was monitored at 13 of these stations, ozone at 11, nitrogen oxides at 4, sulfur dioxide at 3, and hydrocarbons at 1, although operations ceased in May 1984. In addition, 7 of the continuous monitoring stations were monitoring record wind speed and direction, and four of that seven recorded temperature.

Particulate sampling was done at 72 sites by the State. All these stations monitor total suspended particulates. In addition, 8 of these stations sample for particulate matter that is 15 microns in diameter and smaller. Particulate samples from 11 sites were analyzed for sulfates and nitrates. Lead was analyzed for the entire year at 12 sites.

Tables 1-2 and 1-3 present all the monitoring sites in Colorado and indicate which pollutants are monitored at each site. Note that the site numbers in the tables consist of two characters, a number and a letter. The number represents the Air Quality Control Region in which the site is located, and refers to the large numbers on the map in Figure 1-1. The letter corresponds to a circled letter on the maps in Figures 1-1 and 1-2 which represents the site location. Table 1-4, the 1984 Violations Summary, presents the monitoring sites at which violations of primary NAAQS were recorded during 1984.

1.3 Document Organization

This document is divided into chapters by pollutant. Each chapter contains: 1) a description of the nature and sources of that pollutant, 2) its health and welfare effects, 3) a discussion of the standards (current and proposed) for that pollutant, 4) a discussion of the monitoring methods for that pollutant, 5) a table presenting the 1984 monitored data, 6) historical graphs showing most recent and past years data relative to the standard for that pollutant.

Some chapters have health effects tables. This information is probably more detailed and technical than the general reader needs. It is included as a convenience for those who use this document as a reference for more involved research into the impacts of Colorado's air quality.

Criteria Pollutants

Chapters 2 through 7 discuss the "criteria" pollutants for which EPA has promulgated National Ambient Air Quality Standards. These are:

- o Carbon Monoxide
- o Ozone
- o Nitrogen Dioxide
- o Sulfur Dioxide
- o Particulate Matter
- o Lead

Non-Criteria Pollutants

Many pollutants do not currently have National Ambient Air Quality Standards. Some, however, have known adverse effects or play a role in a problem for which standards are contemplated. The Air Pollution Control Division attempts, with limited resources, to monitor certain non-criteria pollutants. This monitoring is done to establish background values for future work, determine possible trends, and provide a broader picture of ambient pollution levels in Colorado.

Non-criteria pollutants that are regularly monitored in selected areas are:

- o Sulfates
- o Nitrates
- o Nitric Oxide
- o Methane
- o Total Hydrocarbons

Chapters 8 through 11 discuss the "non-criteria" pollutants.

TABLE 1-1

NATIONAL AMBIENT AIR QUALITY STANDARDS

<u>POLLUTANT</u>	<u>AVERAGING TIME</u>	<u>CONCENTRATION</u>
Particulates (TSP)	Annual Geometric Mean:	
	Primary	75 $\mu\text{g}/\text{m}^3$
	Secondary	60 $\mu\text{g}/\text{m}^3$ *
	24-Hour:**	
	Primary	260 $\mu\text{g}/\text{m}^3$
	Secondary	150 $\mu\text{g}/\text{m}^3$
Lead (Pb)	Calendar Quarter:	
	Primary	1.5 $\mu\text{g}/\text{m}^3$
Carbon Monoxide (CO)	1-Hour:**	
	Primary	35 ppm (40 mg/m^3)
	8-Hour:**	
	Primary	9 ppm (10 mg/m^3)
Ozone (O_3)	1-Hour:***	
	Primary & Secondary	0.12 ppm (245 $\mu\text{g}/\text{m}^3$)
Nitrogen Dioxide (NO_2)	Annual Arithmetic Mean:	
	Primary & Secondary	0.053 ppm (100 $\mu\text{g}/\text{m}^3$)
Sulfur Dioxide (SO_2)	Annual Arithmetic Mean:	
	Primary	0.03 ppm (80 $\mu\text{g}/\text{m}^3$)
	24-Hour:**	
	Primary	0.14 ppm (365 $\mu\text{g}/\text{m}^3$)
	3-Hour:**	
	Secondary	0.5 ppm (1300 $\mu\text{g}/\text{m}^3$)

*

Federal guideline only.

**

Not to be exceeded more than once per year.

Statistically estimated number of days with exceedances is not to be more than 1.0 per year, averaged over a three year period.

ppm

=

Parts of pollutant per million parts of air.

 $\mu\text{g}/\text{m}^3$

=

Micrograms of pollutant per cubic meter of air at 760 mm Hg and 25°C.

 mg/m^3

=

Milligrams per cubic meter.

Throughout this document, particulate pollutants are measured in $\mu\text{g}/\text{m}^3$ while gaseous pollutants are in ppm. However, some documents refer to gaseous pollutants in $\mu\text{g}/\text{m}^3$ (mg/m^3 for CO). Therefore the standards for the gaseous pollutants are presented here in both units.

FIGURE 1-1

COLORADO AIR QUALITY MONITORING SITES
AND AIR QUALITY CONTROL REGIONS

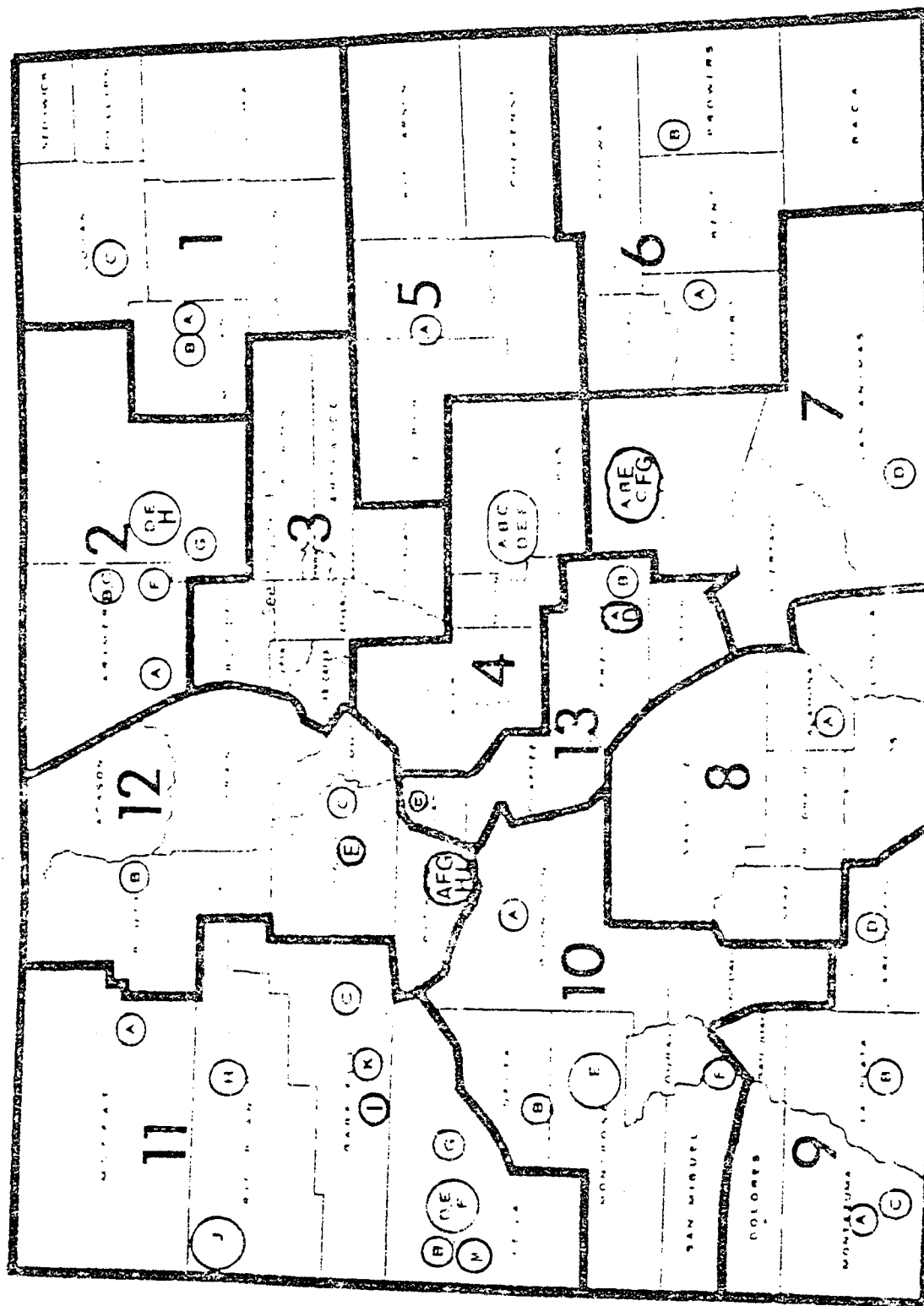


FIGURE 1-2

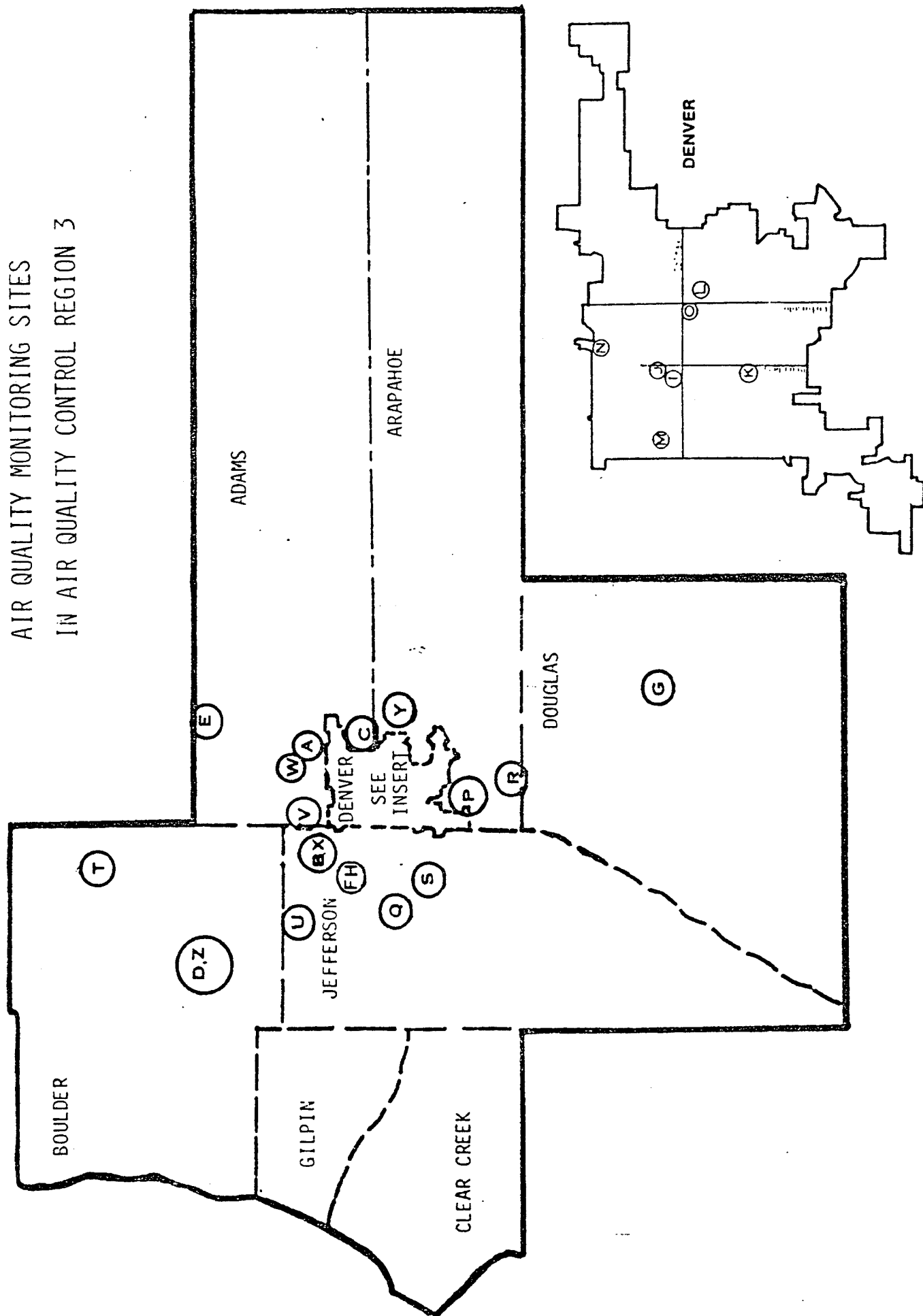


TABLE 1-2

PARTICULATE POLLUTANTS MONITORING SITES

	TSP	=Total Suspended Particulates				
	PM ₁₅	=Particulate Matter less than 15 microns				
	Pb	=Lead				
	SO ₄	=Sulfate				
	NO ₃	=Nitrate				
<u>SITE</u>	<u>LOCATION</u>	<u>TSP</u>	<u>PM₁₅</u>	<u>Pb</u>	<u>SO₄</u>	<u>NO₃</u>
1-A	Brush, Clayton & Edison Sts.	x			x	x
1-B	Fort Morgan, Kiowa & Ensign	x				
1-C	Sterling, 3rd and Ash	x				
2-A	Estes Park, 170 McGregor Ave.	x				
2-B	Fort Collins, 200 W. Oak St.	x	x		x	x
2-D	Greeley, 6th St. & 10th Ave.	x			x	x
2-E	Greeley, 1516 Hospital Road	x				
2-F	Loveland, 4th & Cleveland St.	x				
2-G	Platteville, Town Hall	x				
3-A	Adams City, 4301 E. 72nd Avenue	x		x	x	x
3-B	Arvada, 8101 Ralston Road	x				
3-C	Aurora, 1633 Florence	x				
3-D	Boulder, 13th & Spruce	x				
3-E	Brighton, 15 S. Main St.	x				
3-G	Castle Rock, 310 3rd St.	x				
3-I	Denver, 414 14th Street	x		x		
	Denver, 414 14th St.(Collocated)	x				
3-J	Denver (CAMP) Broadway & 21st	x		x	x	x
3-K	Denver, 1050 S. Broadway	x		x		
3-L	Denver, 4210 E. 11th Avenue	x	x			
3-P	Englewood, 4857 S. Broadway	x				
3-Q	Golden, 911 10th Avenue	x				
3-R	Highland Reservoir, 8100 S. Univ.	x			x	x
3-S	Lakewood, 260 S. Kipling	x				
3-T	Longmont, 4th and Kimbart St.	x				
3-U	Rocky Flats, Plant Entrance	x				
3-V	Westminster, 70th and Utica	x				
4-D	Colorado Springs, 501 N. Foote	x	x	x	x	x
4-E	Colorado Springs, 3730 N. Meadowland Blvd.	x				
4-F	Colorado Springs, 200 S. Cascade	x				
	Colorado Springs, 200 S. Cascade (Collocated)	x				
5-A	Limon, 874 F Ave.	x				
6-A	La Junta, Colorado & 2nd Avenue	x				
6-B	Lamar, Lamar Power Plant	x				

TABLE 1-4

1984 VIOLATIONS SUMMARY

(Monitoring sites at which violations of
primary NAAQS were recorded during 1984)

<u>SITE</u>	<u>LOCATION</u>	<u>CO</u>	<u>O₃</u>	<u>TSP</u>
2-C	Fort Collins, 1820 S. Mason	x		
2-H	Greeley, 811 15th St.	x		
3-A	Adams City, 4301 E. 72nd Ave.			x
3-E	Brighton, 15 S. Main St.			x
3-G	Castle Rock, 310 3rd St.			x
3-I	Denver, 414 14th Street			x
	Denver, 414 14th St. (Collocated)			x
3-J	Denver (CAMP), 21st & Broadway	x		x
3-K	Denver, 1050 Broadway			x
3-M	Denver (Carriage), 23rd & Julian	x	x	
3-O	Denver (NJH East), 14th & Albion	x		
3-P	Englewood, 4857 S. Broadway			x
3-T	Longmont, 4th & Kimbart St.			x
3-V	Westminster, 70th & Utica			x
3-X	Arvada, W. 57th & Garrison	x	x	
3-Z	Boulder, 2320 Marine St.	x	x	
4-A	Colorado Springs, 712 S. Tejon	x		
4-B	Colorado Springs, I-25 & Uintah	x		
9-D	Pagosa Springs, High School			x
10-F	Telluride, 231 W. Colorado			x

1.3.1 Explanation of Data Summary Tables

The Data Summary tables were designed to compare 1984 air quality monitoring data with the standards for each pollutant. Therefore, the data are presented for each averaging time for which standards exist.

An annual average concentration is presented for each pollutant that has an annual standard (NO₂, SO₂, TSP).

For pollutants that have short term standards, the second maximum short-term concentration is presented. With the exception of ozone, the second maximum value is the one that should be compared to the standard. Short-term standards are allowed to be exceeded once per year. If a standard is exceeded twice in one year at a given site, then that site has violated that standard.

For ozone, the standard has a statistical form. A calculation is required that takes into account missing days of data, monitored maximum value and the two previous years of data. The result is a three-year average number of days that exceed the standard, called "expected violation days per year".

Only those stations where 75% or more of the yearly data has been recovered are considered as valid indicators of the ambient air quality for an area. Stations with less than 75% data recovery are indicated by parentheses () around the data in the Data Summary tables, and as an "ID" (insufficient data) on the Historical Comparison graphs.

1.3.2 Explanation of Historical Comparison Graphs

The Historical Comparison graphs present air quality data for 1975 (1974 for TSP, & Pb) through 1984 in order to indicate the variations in air quality from year to year. For simplicity, the historical comparison graphs present air quality data for the single averaging time for each pollutant that represents the standard most exceeded or approached. In addition, for CO and O₃, the graphs also present the number of days in each year on which the standards were violated.

Historical Comparison graphs have been prepared only for current monitoring stations that have at least three years of data. No Historical Comparison graphs are presented for stations that have been moved recently, because air quality data from different locations may not be directly comparable.

1.4 Apparent Trends

A casual inspection of the historical comparison graphs reveals that year-to-year variations in air quality are too erratic for long-term air quality trends to be clearly discernible. However, some general observations can be made. For ozone, a slight improvement in air quality seems to have occurred since the mid 1970's. The number of violation days for carbon monoxide have slightly decreased since the mid 1970's, but the actual second maximum 8-hour carbon monoxide readings do not show a discernible trend. Nitrogen dioxide and sulfur dioxide have remained fairly constant, at levels in compliance with National Ambient Air Quality Standards, for the past several years. Total Suspended Particulate levels have not exhibited any definitive trend. Concentrations of atmospheric lead have decreased considerably in the last few years with all sites now complying with the standard.

2. CARBON MONOXIDE (CO)

2.1 Description and Sources

Carbon monoxide is a colorless, odorless, tasteless gas. It occurs naturally in the air as the result of incomplete combustion processes, such as forest fires, the oxidation of methane, and other natural processes. Natural background concentrations are about .05 - .15 parts per million.¹ This is an insignificant level compared to concentrations found in urban environments, where CO is by far the most abundant pollutant in the atmosphere. Urban atmospheres contain about 100 times as much CO as any other pollutant. Urban carbon monoxide is produced primarily by motor vehicles. In Denver, it is estimated that in 1982, 90% of the CO emissions were from vehicular sources. The remainder originate from other combustion sources such as heating, incineration, power generation, etc.

Because motor vehicle emissions are the major source of CO, daily concentration peaks coincide with morning and evening rush hours. The worst carbon monoxide problems are found where large numbers of slow moving cars congregate, such as in large parking lots or during traffic jams. CO can thus temporarily accumulate to harmful levels, especially in calm weather during autumn and winter, when automobile emissions and fuel combustion for space heating reach their peak. CO problems are worst in winter because: 1) cold weather makes motor vehicles run less efficiently; 2) more combustion for space heating is required; and 3) on winter nights a strong inversion layer develops near the ground trapping the pollutants.

A relatively new source of carbon monoxide has been introduced into urbanized areas in Colorado in recent years. The large scale use of wood for home heating in air tight stoves could contribute up to 10% of the total urban carbon monoxide concentrations according to present calculations.

2.2 Health Effects

Carbon monoxide affects the central nervous system by depriving the body of oxygen. Tests of automobile drivers show exposure to carbon monoxide can impair a driver's judgement and ability to respond rapidly in traffic.³

Carbon monoxide enters the body through the lungs, where it is absorbed by the bloodstream and combines with hemoglobin, the substance that carries oxygen to the cells. Hemoglobin that is bound up with CO is called carboxyhemoglobin. Hemoglobin binds approximately 240 times more readily with CO than with oxygen. Thus, the amount of oxygen being distributed throughout the body by the bloodstream is reduced in CO's presence. Blood laden with CO can weaken heart contractions, lowering the volume of blood distributed to various parts of the body. It can also significantly reduce a healthy person's ability to perform manual tasks, such as working, jogging, and walking. A life-threatening situation exists in patients with heart disease, who are unable to compensate for the oxygen loss. The millions of people in the U.S. suffering from angina pectoris (a heart disease characterized by brief spasmodic attacks of chest pain due to insufficient oxygen levels in the heart muscles) are especially susceptible.

"EPA has concluded that the following groups may be particularly sensitive to exposures of CO: Angina patients, individuals with other types of cardiovascular disease, persons with chronic obstructive pulmonary disease, anemic individuals, fetuses, and pregnant women. Concern also exists for healthy children because of increased oxygen requirements that result from their higher metabolism rate."⁴

Carbon monoxide is exhausted from the body at varying rates depending on physiological as well as external factors. The general guideline is that 20-40% of the CO is lost from the system after 2-3 hours following exposure.¹

Because it takes time for CO to build up in the blood stream, the severity of health effects depends both on the concentration being breathed and the length of time the person is exposed. Table 2-1 displays the relationship between health effects and exposure to CO.

2.3 Standards

There are two current standards for carbon monoxide. They are 9 parts CO per million air (ppm), averaged over a period of 8 hours, and 35 ppm averaged over a 1 hour period. These levels are not to be exceeded more than once per year.⁵ EPA has proposed changes to the form of the NAAQS for carbon monoxide. Considerable debate centers around the form and the appropriate concentrations for the revised standard. It is anticipated any revised standard will be in a statistical form that accounts for missing data. However, the current 9 ppm, 8-hour average, is expected to be retained.

2.4 Monitoring

Carbon monoxide was monitored by the State at 13 stations in 1984 (see Table 2-2) using continuous non-dispersive infrared (NDIR) analyzers.

Tables 2-2 and 2-3 are the 1984 Data Summary for CO. Table 2-2 presents 1-hour concentrations. Table 2-3 presents 8-hour average concentrations. In both tables, two columns display CO violation statistics. The first, number of violations, relates directly to the form of the existing standard. The second, violation days, is used for trending analysis in an attempt to smooth out extreme year to year fluctuations. The difference between the two columns reflects the fact that more than one period in a day may violate the standard. Figure 2-1 presents the CO Historical Comparison graphs. The lower graph on each page presents the number of violation days each year, from the second column of Table 2-3.

TABLE 2-1

ESTIMATED HEALTH EFFECTS LEVELS FOR CARBON MONOXIDE EXPOSURE¹

EFFECTS	COHb CONCENTRATION	EXPOSURE DURATION	
		<u>1 HOUR</u>	<u>8 HOUR</u>
Physiological Normal	0.30-0.70%	0 ppm	0 ppm
Possible aggravation of angina pectoris, decreased exercise capacity in angina patients, and individuals with peripheral arterioclerosis.	3.0%	29-85	6-18
Decreased exercise capacity in both impaired and normal subjects. Impairment of vigilance tasks in healthy experimental subjects	3.0-6.5%	85-207	18-45
Linear relationship between COHb and decreasing maximal oxygen consumption during strenuous exercise in young healthy men.	5.0-20%	155-175	33-170

TABLE 2-2

CARBON MONOXIDE (CO)

1984 DATA SUMMARY
(1-hour concentrations - parts per million)

Standard = 35 ppm

<u>SITE</u>	<u>LOCATION</u>	<u>NUMBER OF VIOLATIONS</u>	<u>VIOLATION DAYS</u>	<u>DAYS MONITORED</u>	<u>SECOND HIGHEST</u>	<u>HIGHEST</u>
2-C	Fort. Collins, 1810 S. Mason	0	0	344	26	26
2-H	Greeley, 811 15th Street	0	0	346	24	29
3-X	Arvada, W. 57th & Garrison	0	0	363	20	21
3-Y	Aurora, 50 S. Peoria	0	0	359	12	13
3-Z	Boulder, 2320 Marine St	0	0	332	14	15
3-J	Denver (CAMP), 21st & Broadway	3	3	358	38	44
3-M	Denver (Carriage), 23rd Ave. & Julian	0	0	357	23	24
3-0	Denver, (NJH East) 14th & Albion	0	0	355	25	31
3-R	Highland Reservoir, 8100 S. Univ.	0	0	360	7	9
4-A	Colorado Springs, 712 S. Tejon	0	0	341	23	25
4-B	Colorado Springs, I-25 & Uintah	0	0	354	27	30
7-A	Pueblo, 151 Central Main	0	0	347	16	16
11-F	Grand Junction, 711 Independent	0	0	287	11	11

TABLE 2-3

CARBON MONOXIDE (CO)

1984 DATA SUMMARY

(8-hour average concentrations- parts per million)

Standard = 9 ppm

<u>SITE</u>	<u>LOCATION</u>	<u>NUMBER OF VIOLATIONS</u>	<u>VIOLATION DAYS</u>	<u>DAYS MONITORED</u>	<u>SECOND HIGHEST</u>	<u>HIGHEST</u>
2-C	Fort Collins, 1810 S. Mason	7	6	344	16	19
2-H	Greeley, 811 15th Street	6	6	346	16	17
3-X	Arvada, W. 57th & Garrison	13	10	363	11	12
3-Y	Aurora, 50 So. Peoria	0	0	359	6	6
3-Z	Boulder, 2320 Marine St.	2	2	332	10	10
3-J	Denver (CAMP), Broadway & 21st St.	57	41	358	20	21
+3-M	Denver (Carriage), 23rd Ave. & Julian	27	25	357	15	15
+3-O	Denver (NJH East), 14th & Albion	19	18	355	15	15
3-R	Highland Reservoir, 8100 S. Univ.	0	0	360	5	5
4-A	Colorado Springs, 712 S. Tejon	1	1	341	9	10
4-B	Colorado Springs, I-25 & Uintah	12	7	354	11	12
7-A	Pueblo, 151 Central Main	0	0	347	6	6
11-F	Grand Junction, 711 Independent	0	0	287	6	7

+ This site is not shown graphically since it has less than 3 years of data.

FIGURE 2-1

CARBON MONOXIDE EIGHT-HOUR CONCENTRATIONS
HISTORICAL COMPARISONS

AQCR #2

FT. COLLINS
1810 S. Mason

GREELEY
811 15th Street

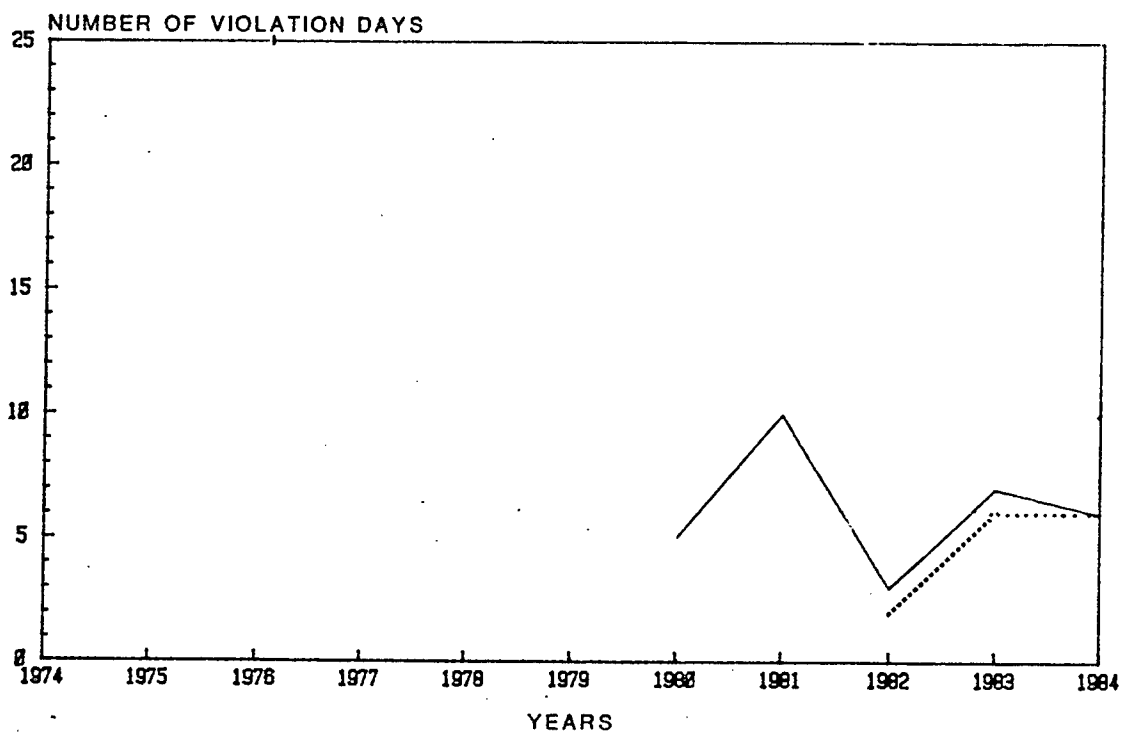
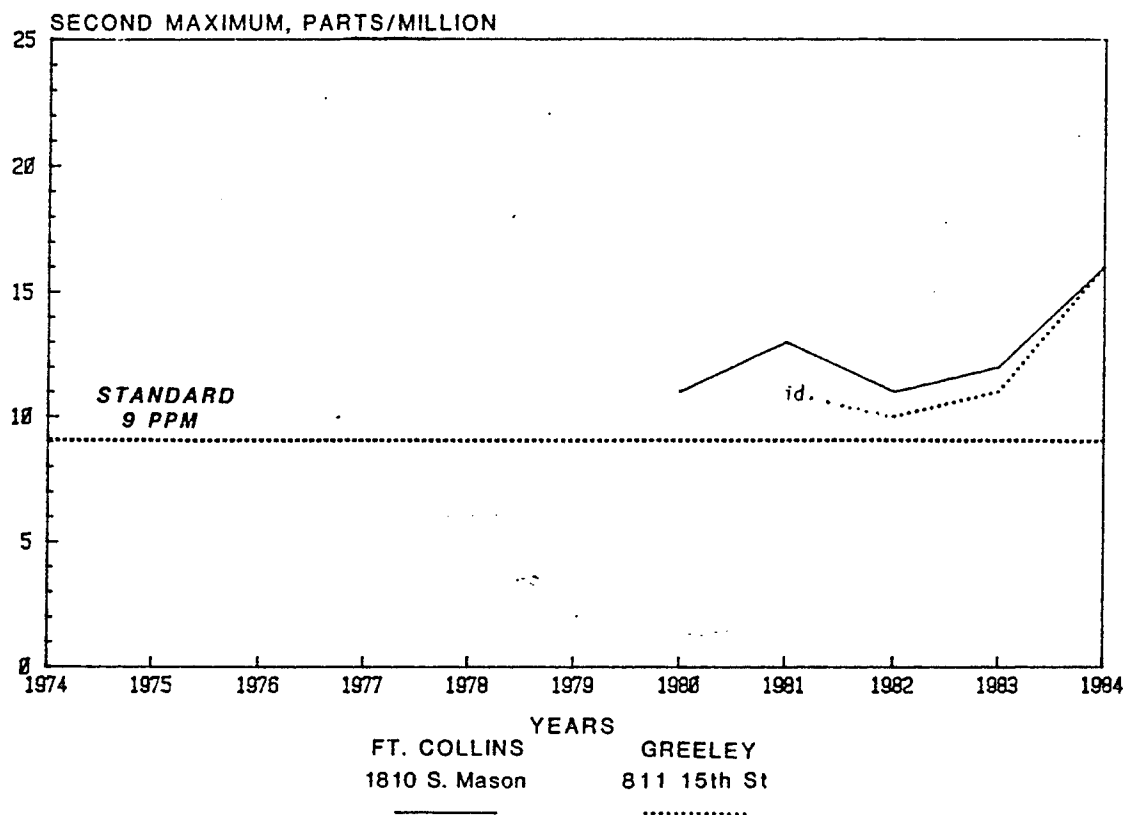


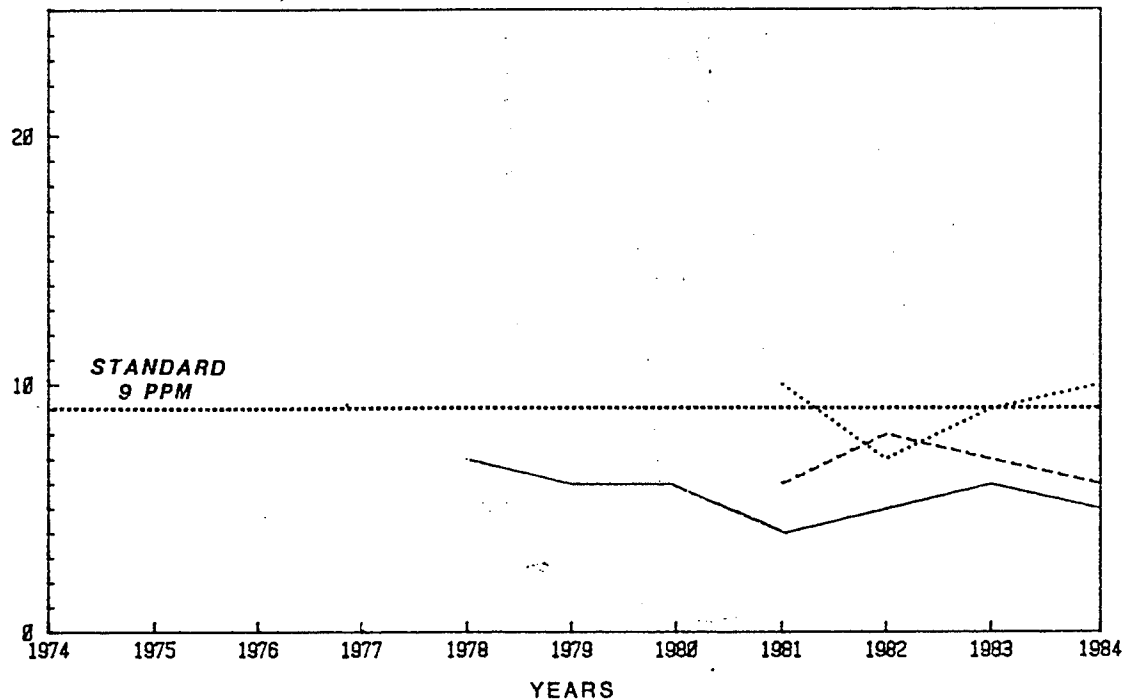
FIGURE 2-1 (continued)

CARBON MONOXIDE EIGHT-HOUR CONCENTRATIONS
HISTORICAL COMPARISONS

AQCR #3

HIGHLAND RESERVOIR 8100 S. University	AURORA 50 S. Peoria	BOULDER 2320 Marine St.
—————	-----

SECOND MAXIMUM, PARTS/MILLION



HIGHLAND RESERVOIR 8100 S. University	AURORA 50 S. Peoria	BOULDER 2320 Marine St.
—————	-----

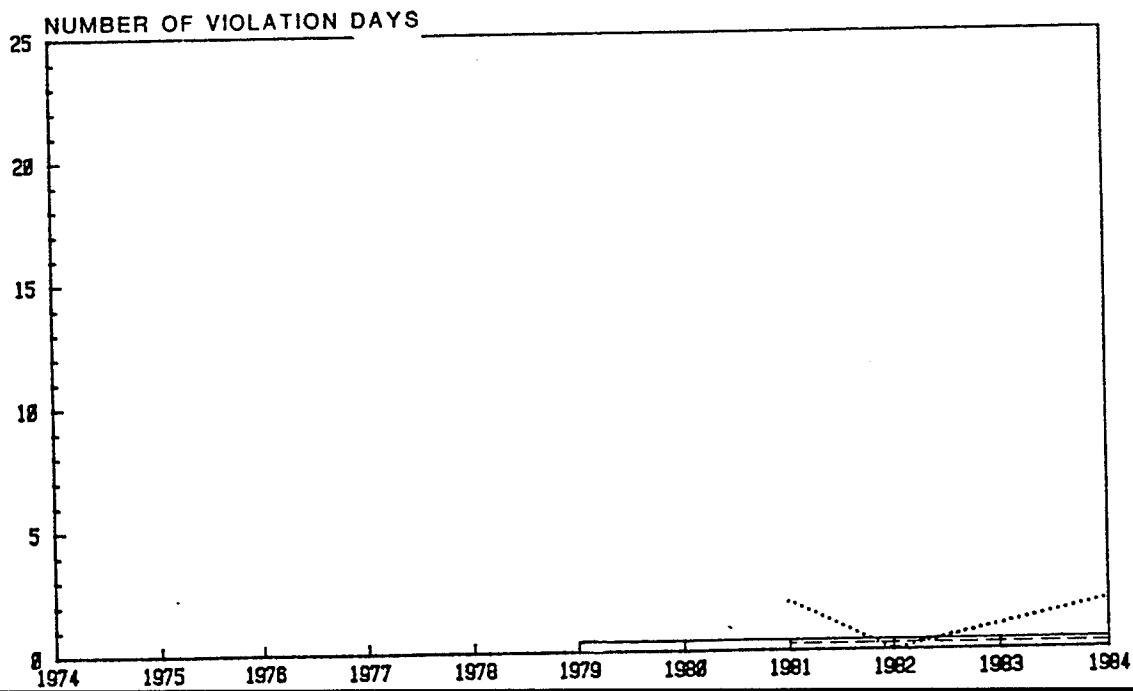


FIGURE 2-1 (continued)

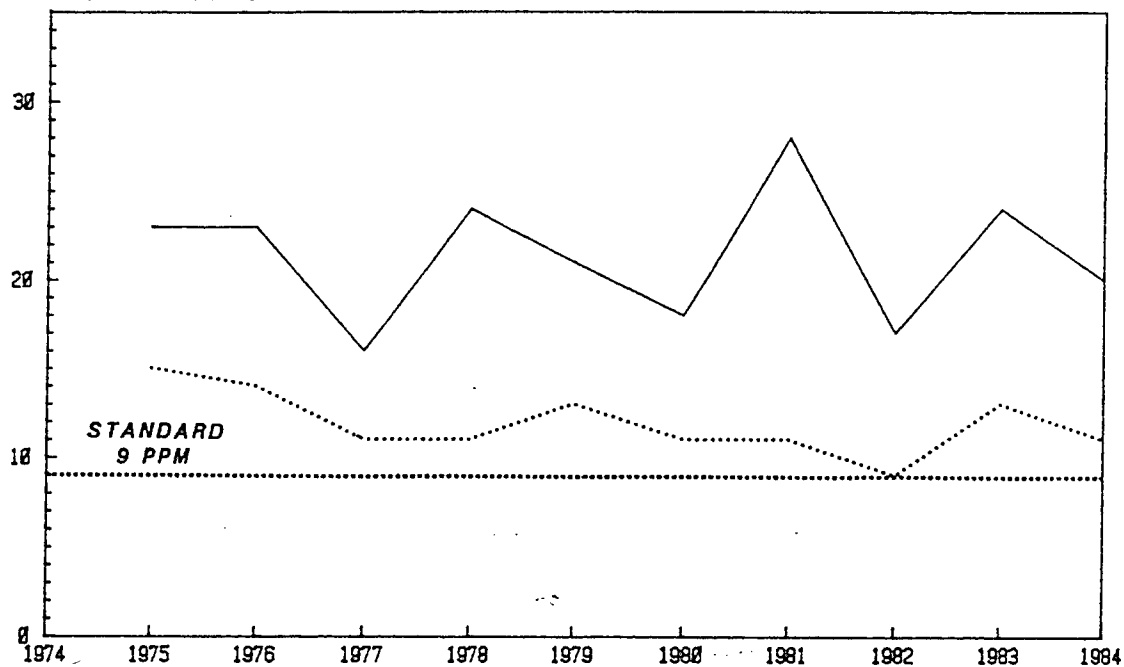
CARBON MONOXIDE EIGHT-HOUR CONCENTRATIONS
HISTORICAL COMPARISONS

AQCR #3

DENVER, CAMP
21st & Broadway

ARVADA
57th & Garrison

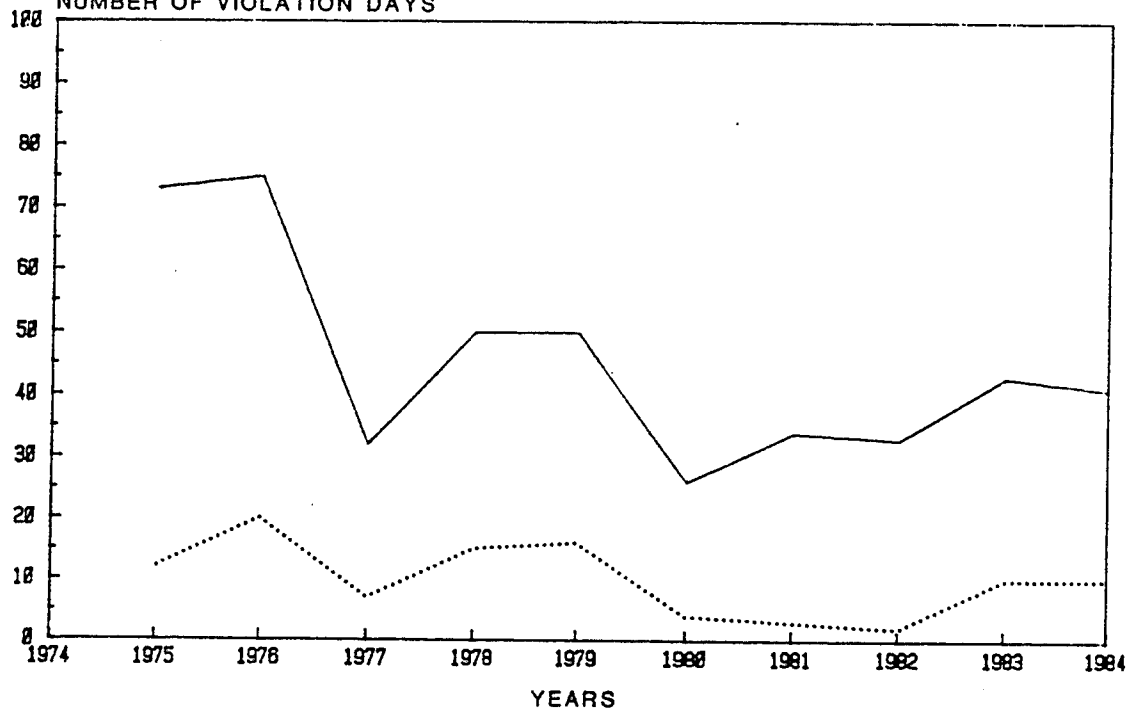
SECOND MAXIMUM PARTS/MILLION



DENVER, CAMP
21st & Broadway

ARVADA
57th & Garrison

NUMBER OF VIOLATION DAYS



YEARS

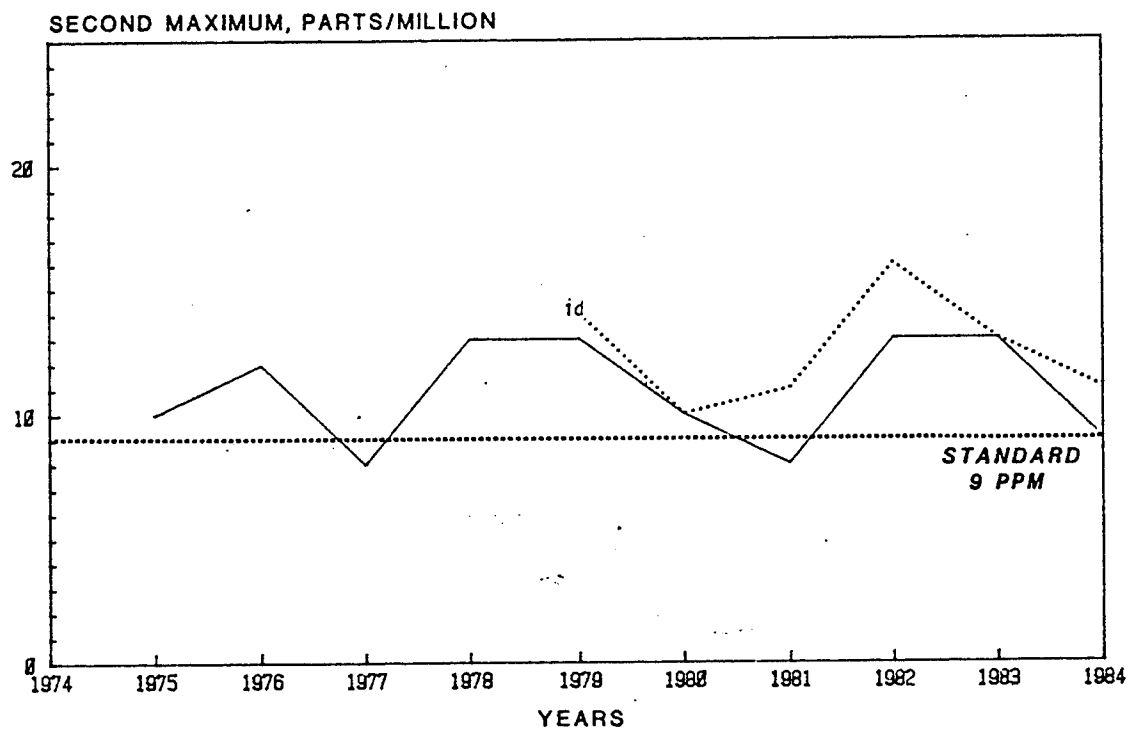
FIGURE 2-1 (continued)

CARBON MONOXIDE EIGHT-HOUR CONCENTRATIONS
HISTORICAL COMPARISONS

AQCR #4

COLORADO
SPRINGS
712 S. Tejon

COLORADO
SPRINGS
I-25 & Uintah



COLORADO
SPRINGS
712 S. Tejon

COLORADO
SPRINGS
I-25 & Uintah

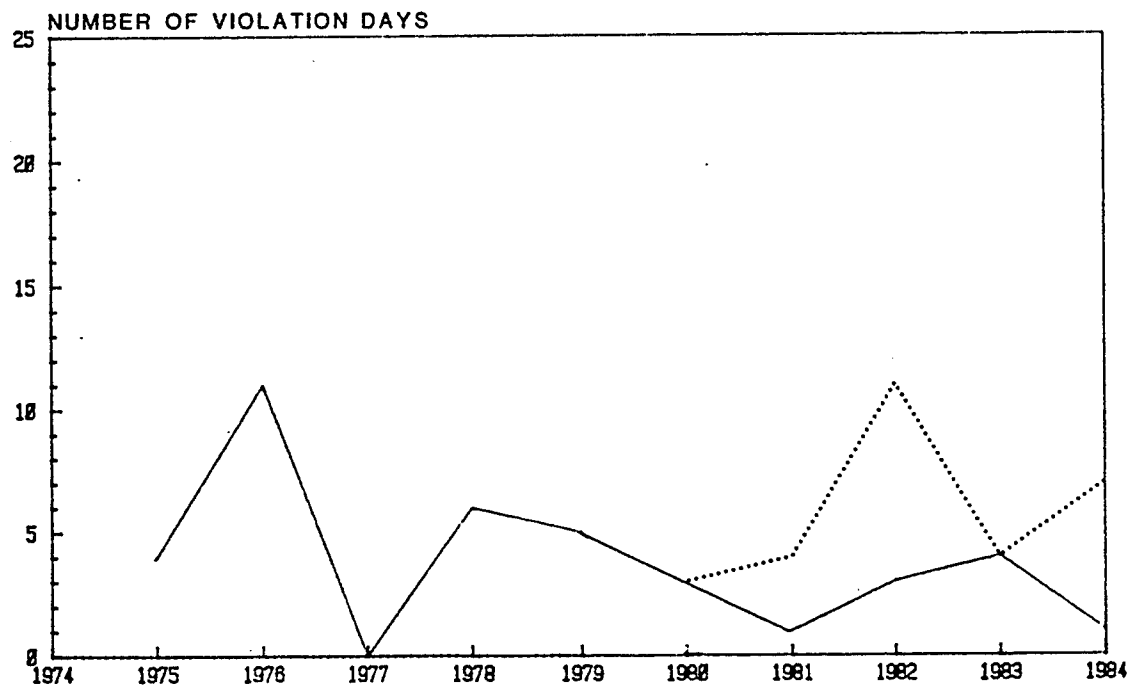
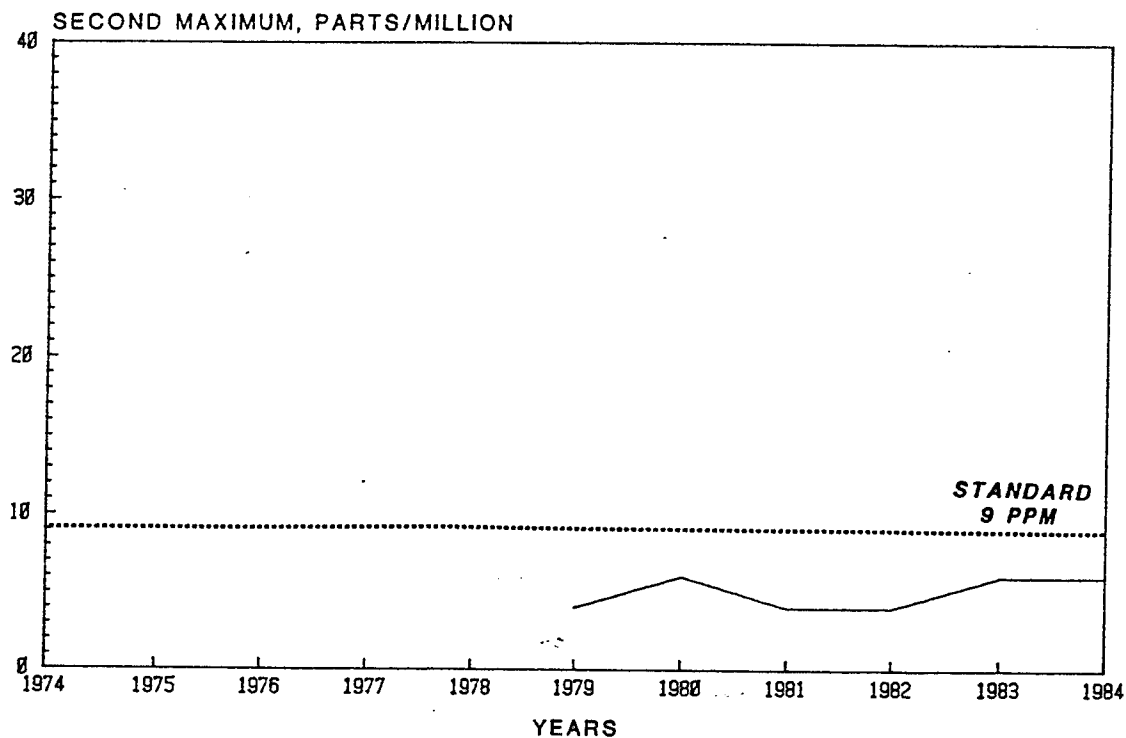


FIGURE 2-1 (continued)

CARBON MONOXIDE EIGHT-HOUR CONCENTRATIONS
HISTORICAL COMPARISONS

AQCR #7

PUEBLO
151 Central Main



PUEBLO
151 Central Main

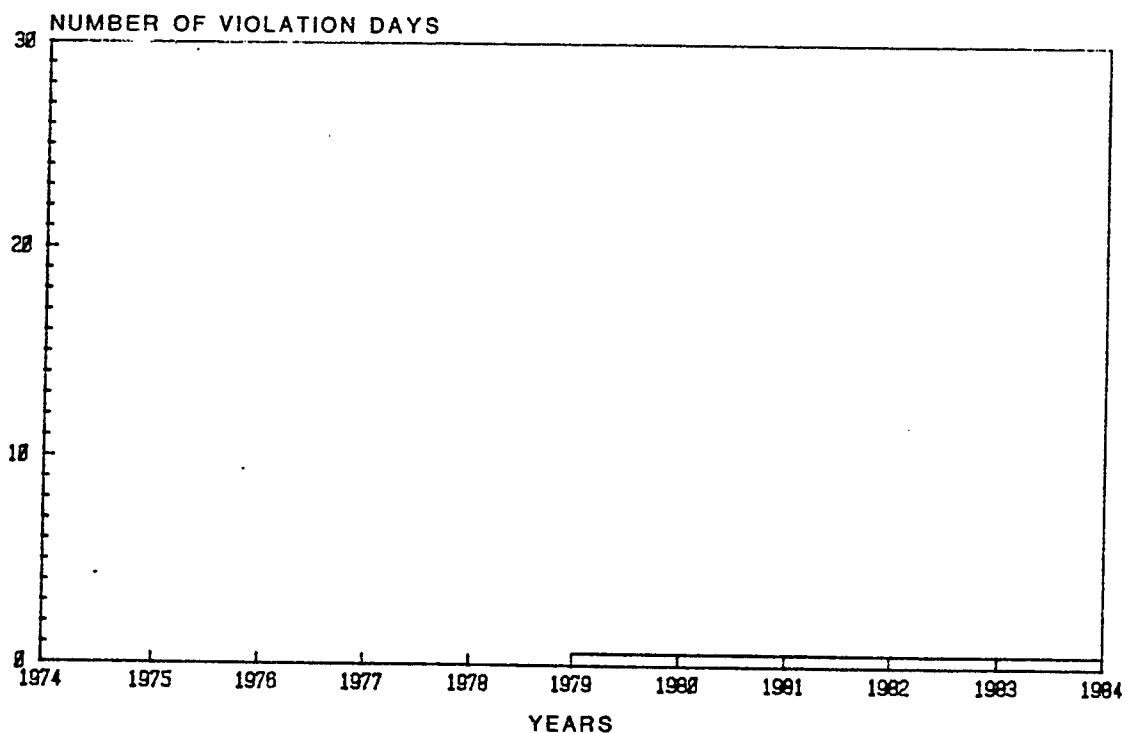


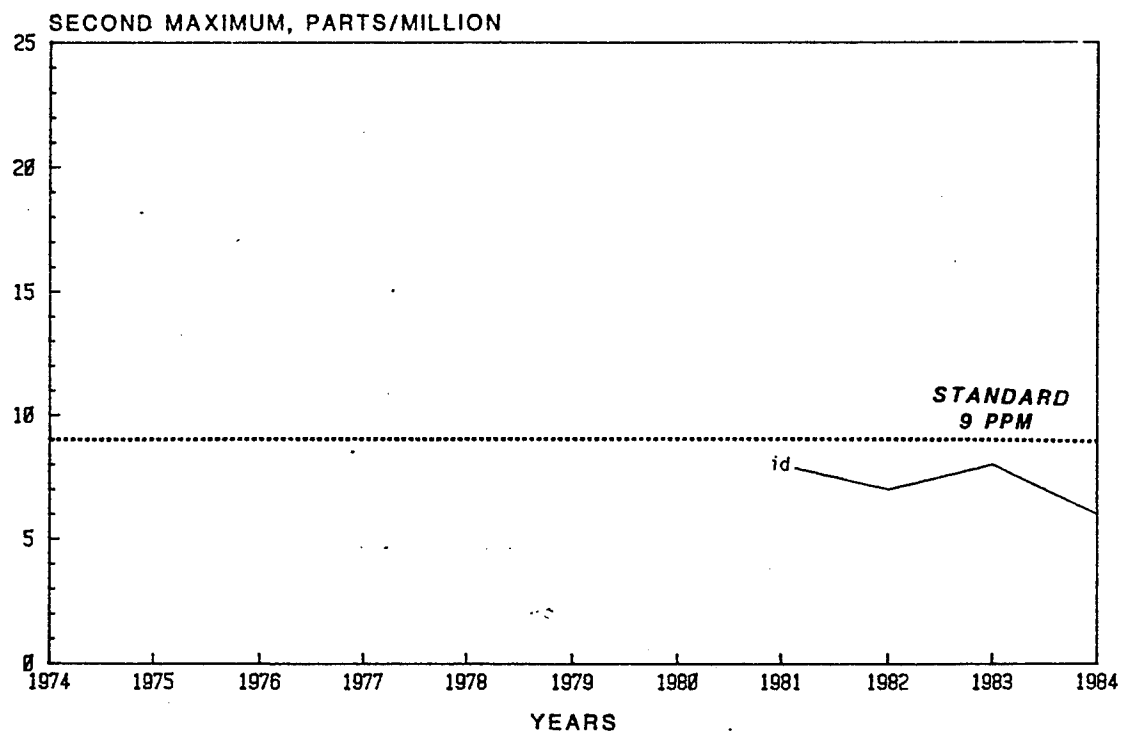
FIGURE 2-1 (continued)

CARBON MONOXIDE EIGHT-HOUR CONCENTRATIONS
HISTORICAL COMPARISONS

AQCR #11

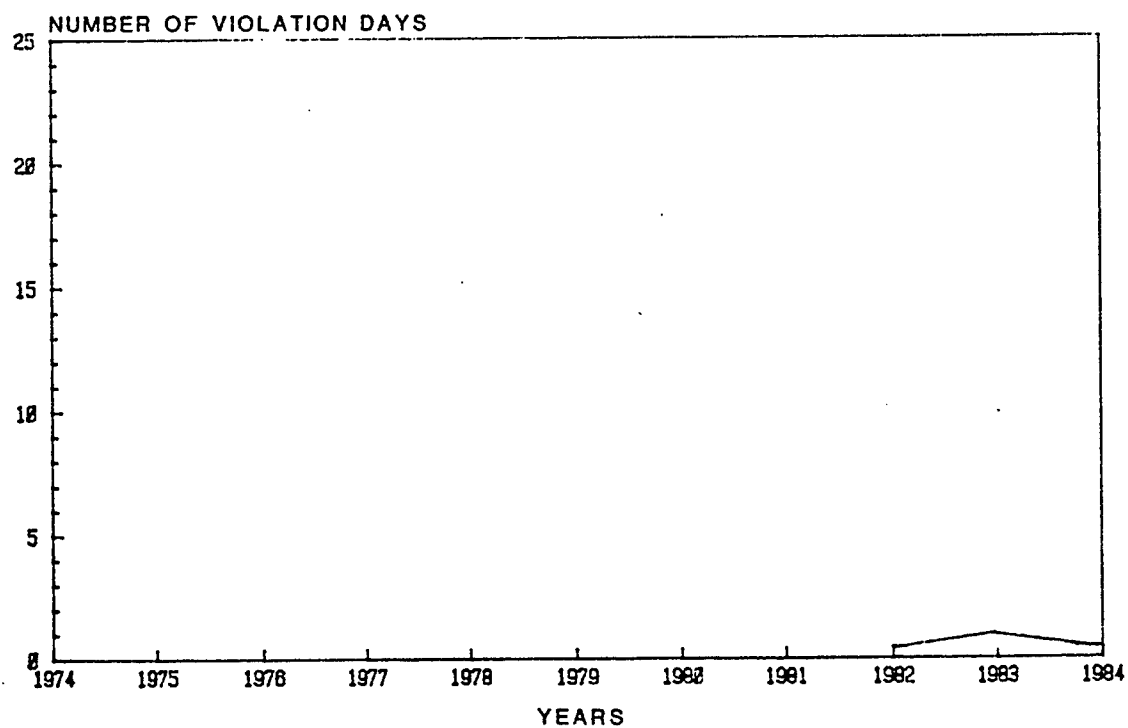
GRAND JUNCTION

711 Independent



GRAND JUNCTION

711 Independent



3. OZONE (O₃)

3.1 Description and Sources

Ozone is a highly reactive form of oxygen. At very high concentrations it is a blue unstable gas with a characteristic pungent odor. It can often be detected around an arcing electric motor, lightning storms, or other electrical discharges.⁶ However, at normal ambient concentrations, ozone is colorless and odorless. While ozone is a major component of photochemical "smog", the haziness and odors of smog are caused primarily by other components.

Natural ground level ozone occurs in low concentrations (less than .05 ppm) due to natural physical and chemical phenomena. Ground-level ozone should not be confused with the stratospheric ozone layer which is located about seven miles high in the atmosphere and which shields the earth from cancer-causing ultraviolet rays. Concentrations of ozone in this layer can reach as high as 10 ppm. Concern over potential reduction of the necessary levels of ozone in the stratosphere by reactions with fluorocarbons from aerosol cans has resulted in the removal of most of these propellants from the market. However, ozone at ground level, where it can be breathed, is a pollutant.⁷ Occasionally, unique meteorological conditions can result in stratospheric ozone being brought to ground level causing concentrations between 0.50 and 0.10 ppm. There have been cases where this phenomenon, known as stratospheric intrusion, has been reported to have caused concentrations in excess of the 0.12 ppm NAAQS.

Ozone is not emitted directly from a source as are other pollutants, but forms as a secondary pollutant. Its precursors are certain reactive hydrocarbons and nitrogen oxides, which chemically react in sunlight to form ozone. (See Figure 3-1) The reactive hydrocarbons are emitted in automobile exhaust, from gasoline and oil storage and transfer, and from industrial use of paint solvents, degreasing agents, cleaning fluids, ink solvents, incompletely burned coal or wood and many other sources. Plants also give off some reactive hydrocarbons, for example, terpenes from pine trees.⁷ Nitrogen oxides are emitted by sources when nitrogen in the air combines with oxygen during high temperature combustion.

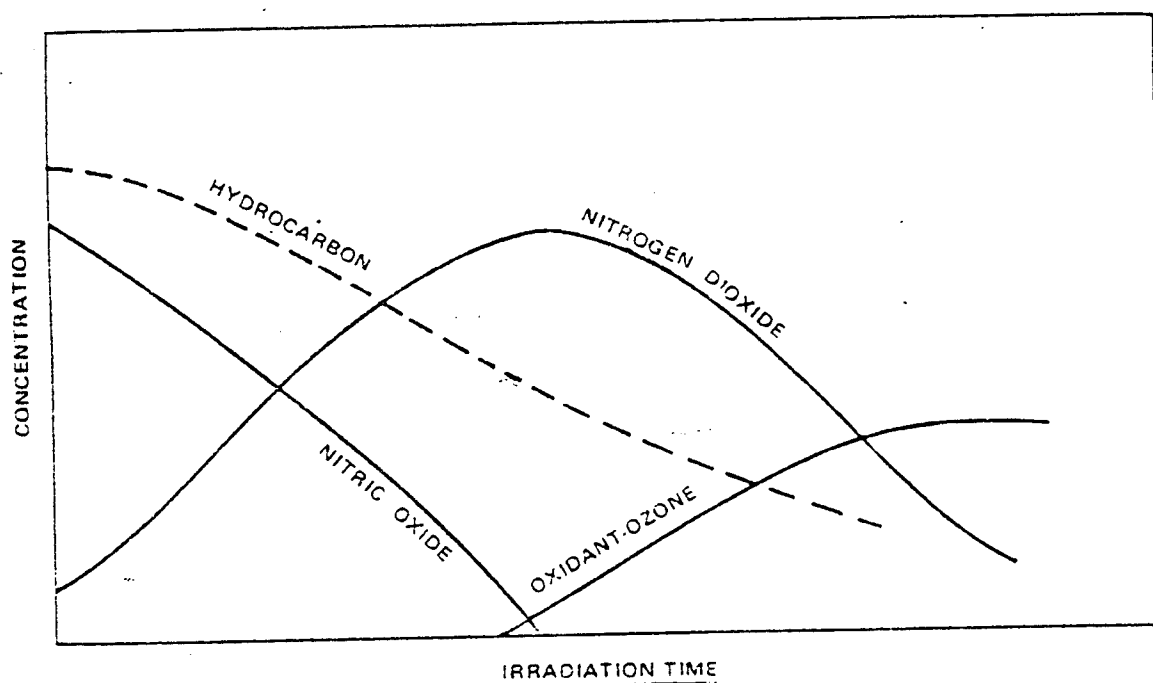
Ozone production is a year around phenomenon. However, the highest ozone levels generally occur during the summer season. Strong sunlight and stagnant meteorological conditions can cause reactive pollutants to remain in an area for several days. Ozone produced under these conditions can be transported many miles outside the urban environment.

3.2 Health and Welfare Effects

Short term exposure to ozone in the range of 0.15 to 0.25 ppm may impair mechanical functions of the lung and may induce respiratory and related symptoms in sensitive individuals. Symptoms and effects of ozone exposure are more readily induced in exercising subjects. Many plants, such as white pine, soybeans and alfalfa, are extremely sensitive to ozone. The deterioration of nylon and other synthetics, as well as degradation of rubber products (especially splitting and cracking of tires and windshield wiper blades), are associated with ozone.⁷ Table 3-1 contains a summary of ozone health effects expected at various exposure levels.

FIGURE 3-1

PHOTOCHEMICAL INTERACTIONS OF HC, NO_x, AND O_x*²⁹



Chemical changes occurring during photoirradiation of hydrocarbon-nitrogen oxide-air systems.

* - Oxidants include nitrates such as PAN, along with ozone and other oxidizing chemicals.

TABLE 3-1

ESTIMATED HEALTH EFFECTS LEVELS FOR OZONE (OXIDANT) EXPOSURE⁷

EFFECTS	EXPOSURE DURATION
Lung function parameters correlated with concentrations over the range of 0.01-0.30 PPM. Decreased athletic performance above 0.15 PPM. Increased rates of respiratory symptoms and headache above 0.16 PPM oxidant levels. Subjective symptoms of discomfort observed with discernable changes in respiratory pattern during exercise.	0.01-0.30 PPM for 1-2 Hours.
Reduction in visual acuity. Some studies showed moderate lung function changes. Increased asthma attack rates at higher levels.	0.20-0.25 PPM for 2-4 Hours.

3.3 Standards

On February 8, 1979, the ozone standard was changed to a statistical form that accounts for missing data in estimating total yearly violations. The three year average of these yearly estimates is the expected number of violations. The standard is attained " . . . when the expected number of days per calendar year with a maximum hourly average concentrations above 0.12 ppm is equal to or less than one".

3.4 Monitoring

The State of Colorado operated ozone monitors at 11 locations in 1984 (see Table 3-2) using two kinds of continuous monitoring equipment: chemiluminescence and ultra-violet absorption analyzers.

Table 3-2 is the 1984 Data Summary for O₃. Two columns display ozone violation statistics. The first, "Expected violation days per year" is the three-year average derived by the statistical method required by the form of the standard discussed in Section 3.3 above. The second is the estimated number of violation days in 1984, considering missing data. Figure 3-2 presents the O₃ Historical Comparison graphs. The lower graph on each page presents the annually estimated violation days from the second column of Table 3-2.

TABLE 3-2

OZONE (O₃)1984 DATA SUMMARY
(parts per million)Standard = 0.12 ppm

<u>SITE</u>	<u>LOCATION</u>	<u>EXPECTED VIOLATION DAYS PER YEAR*</u>	<u>ESTIMATED VIOLATION DAYS THIS YEAR</u>	<u>DAYS MONITORED</u>	<u>SECOND HIGHEST DAILY MAX HR.</u>	<u>HIGHEST DAILY MAX HR.</u>
2-C	Fort Collins, 1810 S. Mason	0.0	0.0	361	.09	.09
2-H	Greeley, 811 15th Street	0.0	0.0	349	.10	.12
3-X	Arvada, W. 57th & Garrison	3.5	2.3	309	.13	.14
3-Y	Aurora, 50 S. Peoria	0.0	0.0	362	.10	.11
3-Z	Boulder, 2320 Marine St.	0.8	1.1	340	.12	.13
3-J	Denver (CAMP), 21st & Broadway	0.0	0.0	355	.09	.09
+3-M	Denver (Carriage), 23rd and Julian	4.7	2.2	330	.12	.13
3-R	Highland Reservoir, 8100 S. University	2.4	0.0	364	.11	.11
3-W	Welby, 78th & Steele	1.4	0.0	360	.10	.11
4-A	Colorado Springs, 712 S. Tejon	0.0	0.0	322	.09	.09
4-C	Security, Academy Blvd. & Hwy. 85	0.0	0.0	344	.07	.07

* 3 - year average

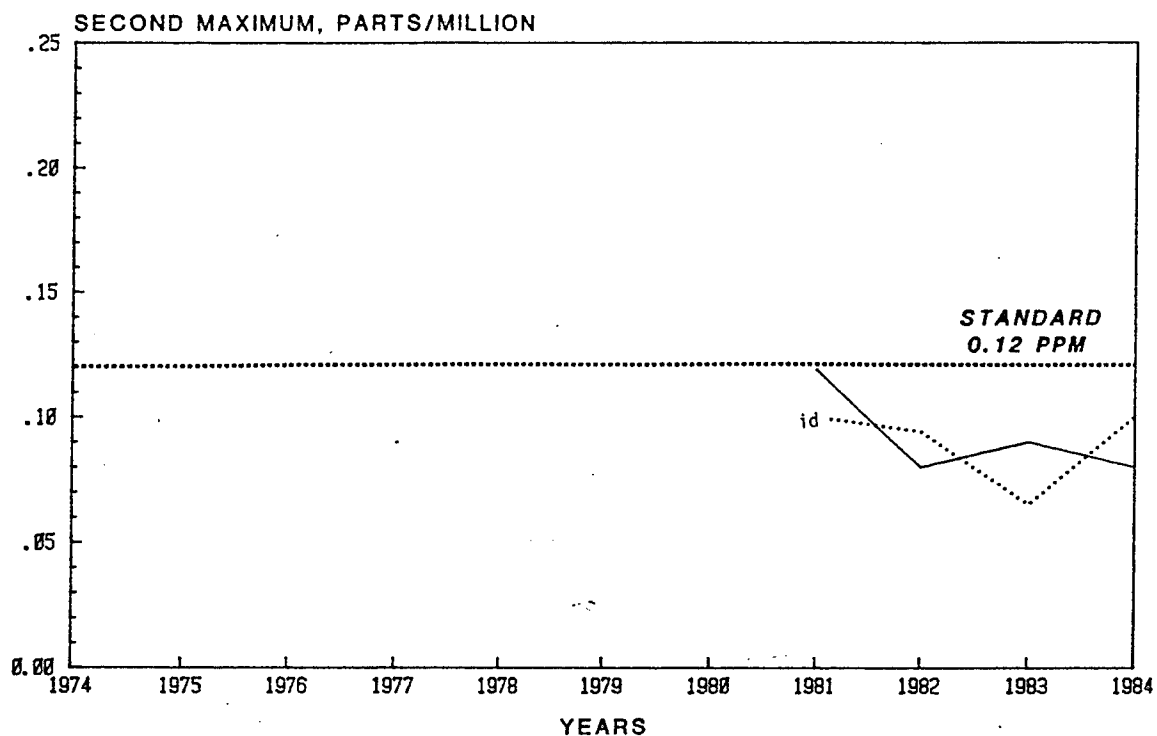
+ The Carriage site has only two years of sufficient data and is not shown graphically.

FIGURE 3-2

OZONE
HISTORICAL COMPARISONS
AQCR #2

FT. COLLINS
1810 S. Mason

GREELEY
811 15th Street



FT. COLLINS
1810 S. Mason

GREELEY
811 15th Street

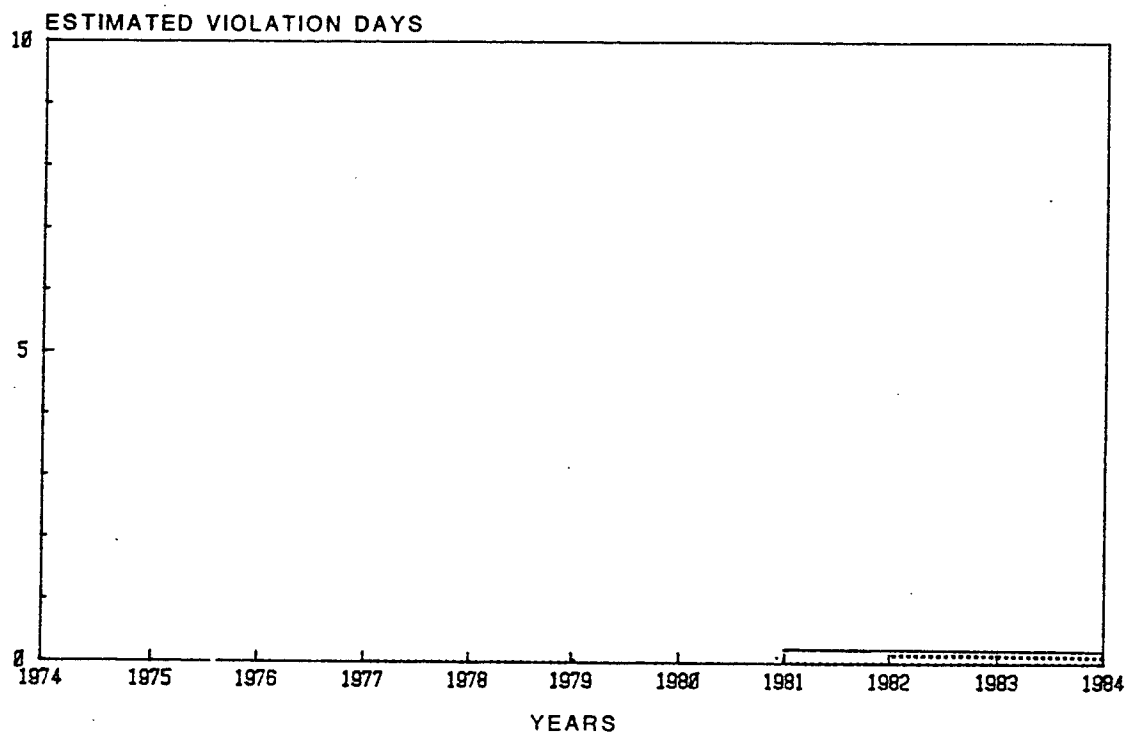


FIGURE 3-2 (continued)

OZONE
HISTORICAL COMPARISONS
AQCR #3

HIGHLAND
RESERVOIR
8100 S. University

WELBY
72nd & Steele

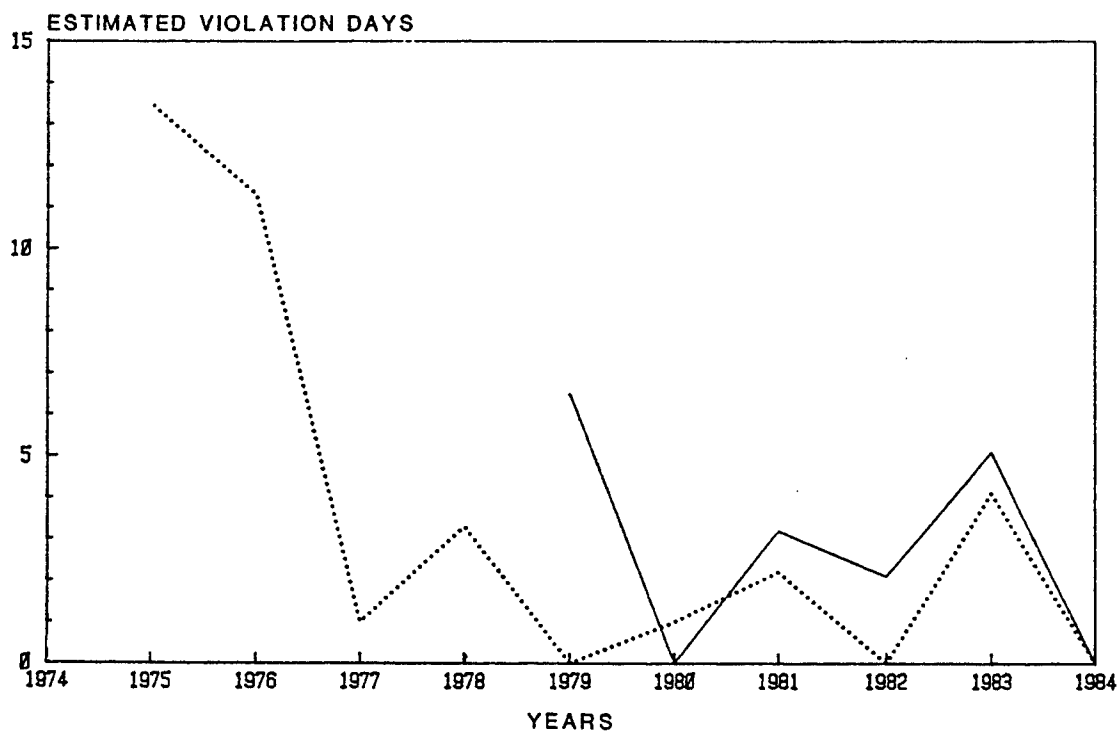
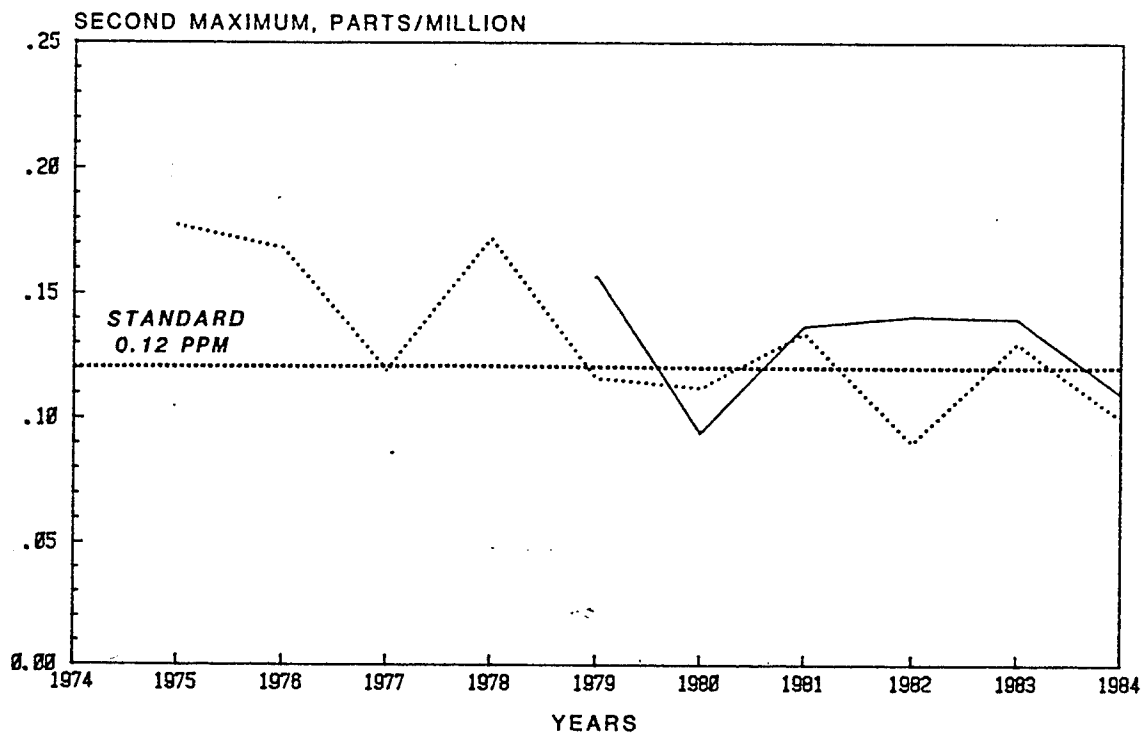


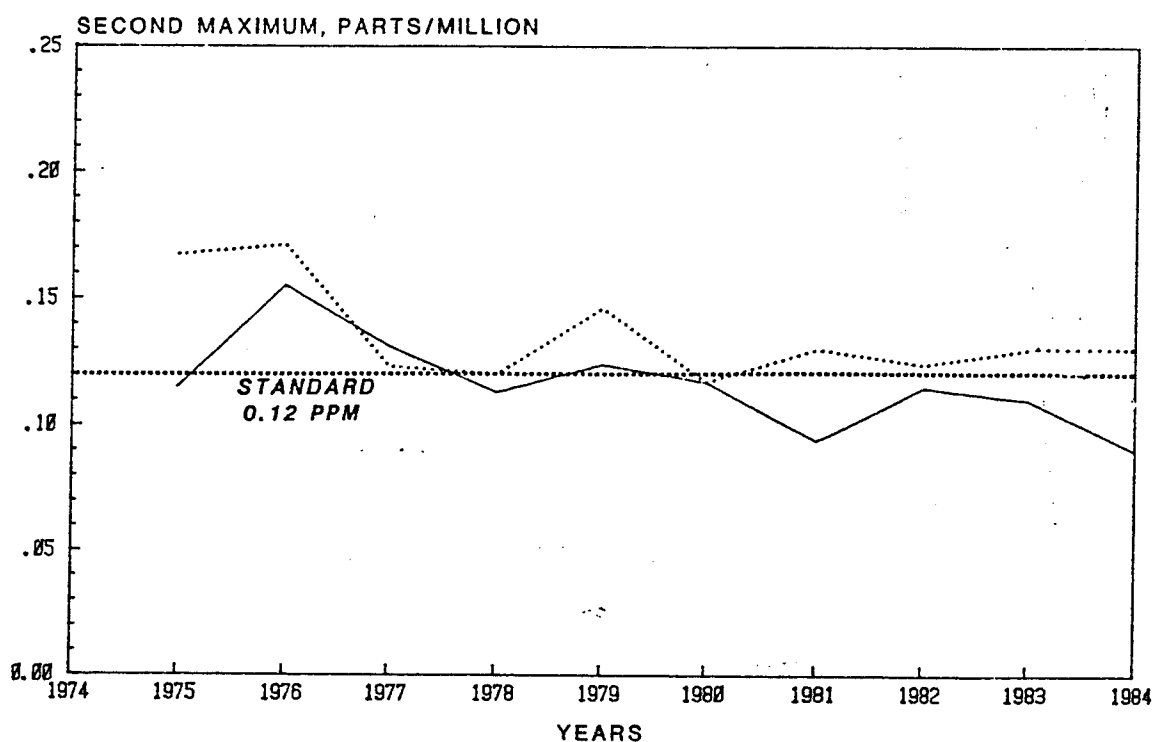
FIGURE 3-2 (continued)

OZONE
HISTORICAL COMPARISONS

AQCR #3

DENVER, CAMP
21st & Broadway

ARVADA
57th & Garrison



DENVER, CAMP
21st & Broadway

ARVADA
57th & Garrison

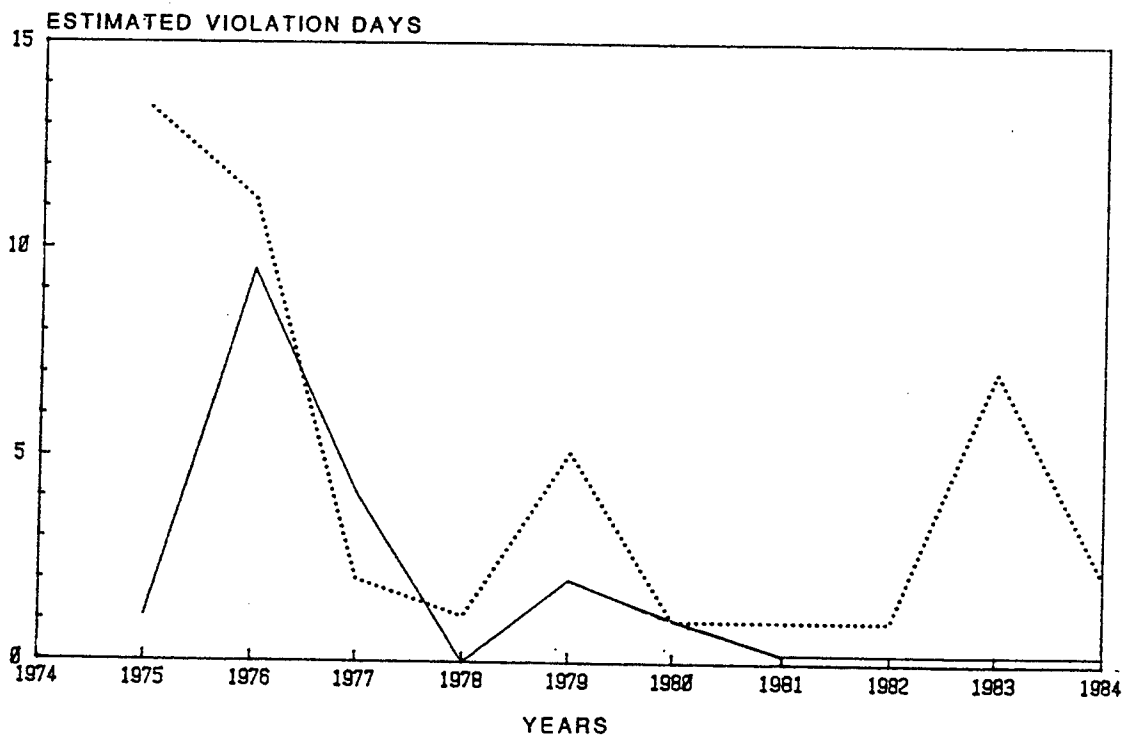


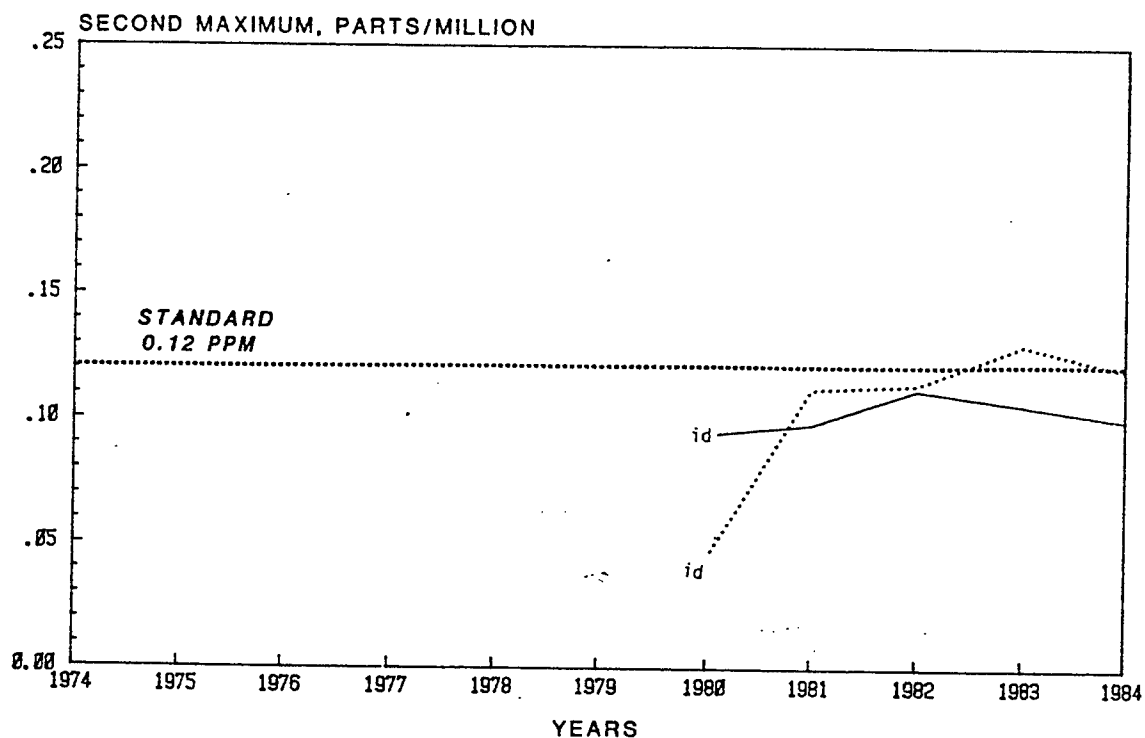
FIGURE 3-2 (continued)

OZONE
HISTORICAL COMPARISONS

AQCR #3

AURORA
50 S. Peoria

BOULDER
2320 Marine St.



AURORA
50 S. Peoria

BOULDER
2320 Marine St.

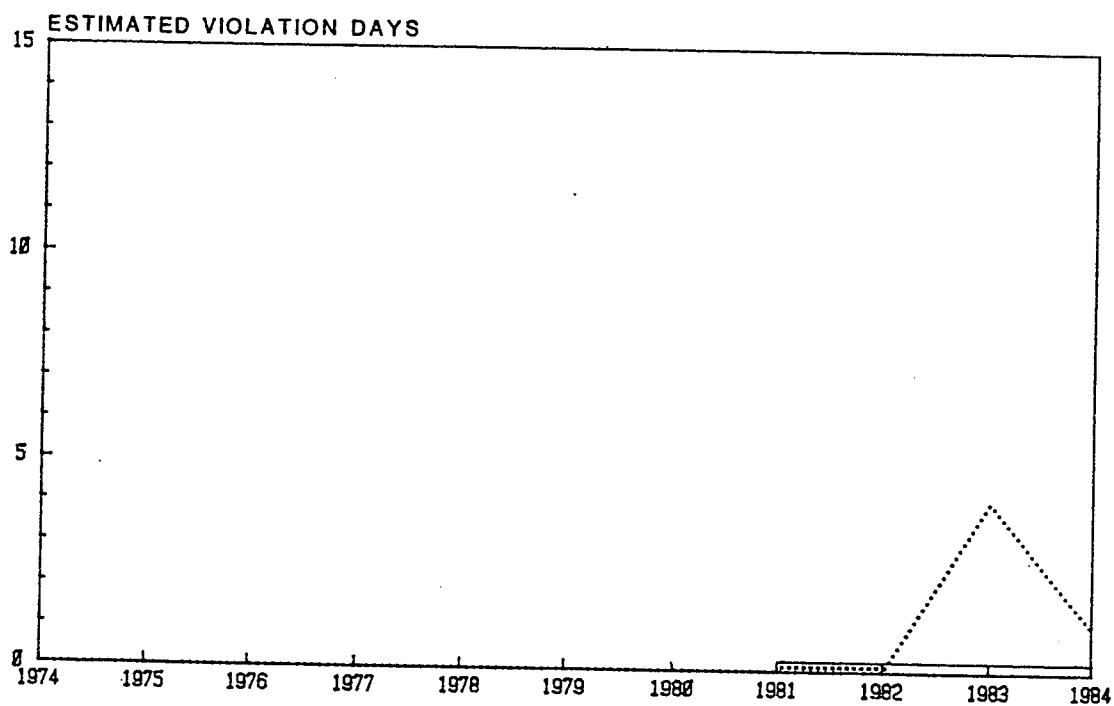
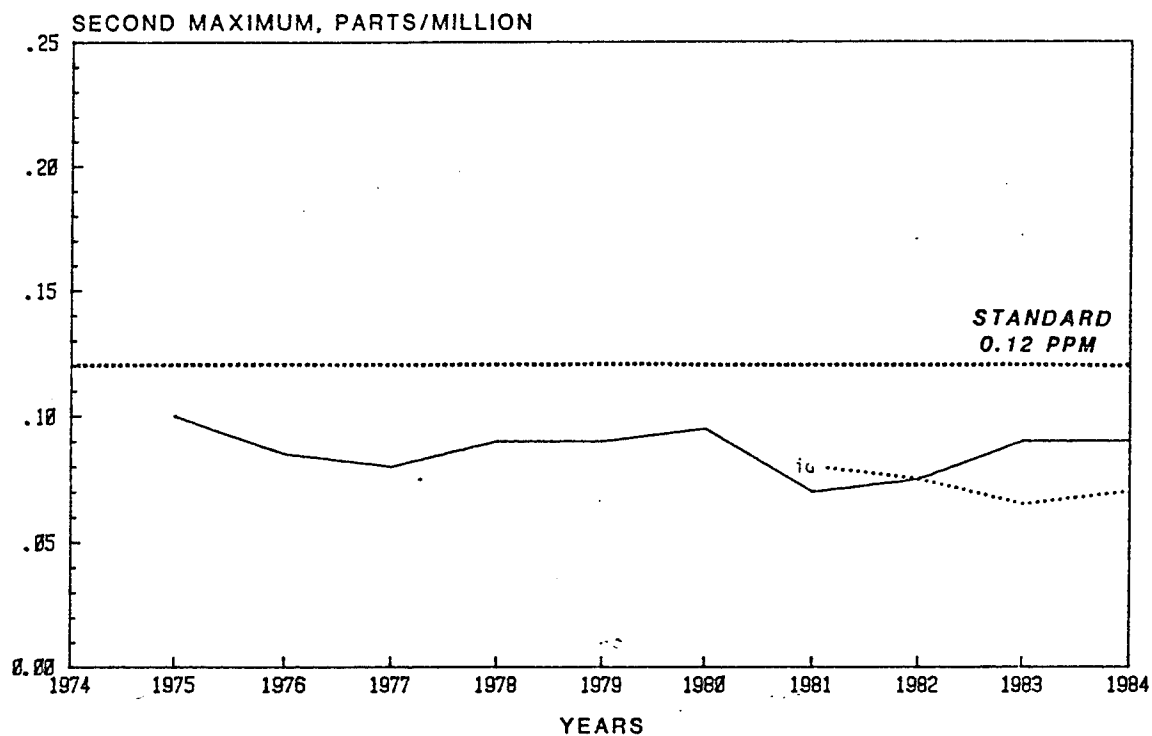


Figure 3-2 (continued)

OZONE
HISTORICAL COMPARISONS
AQCR #4

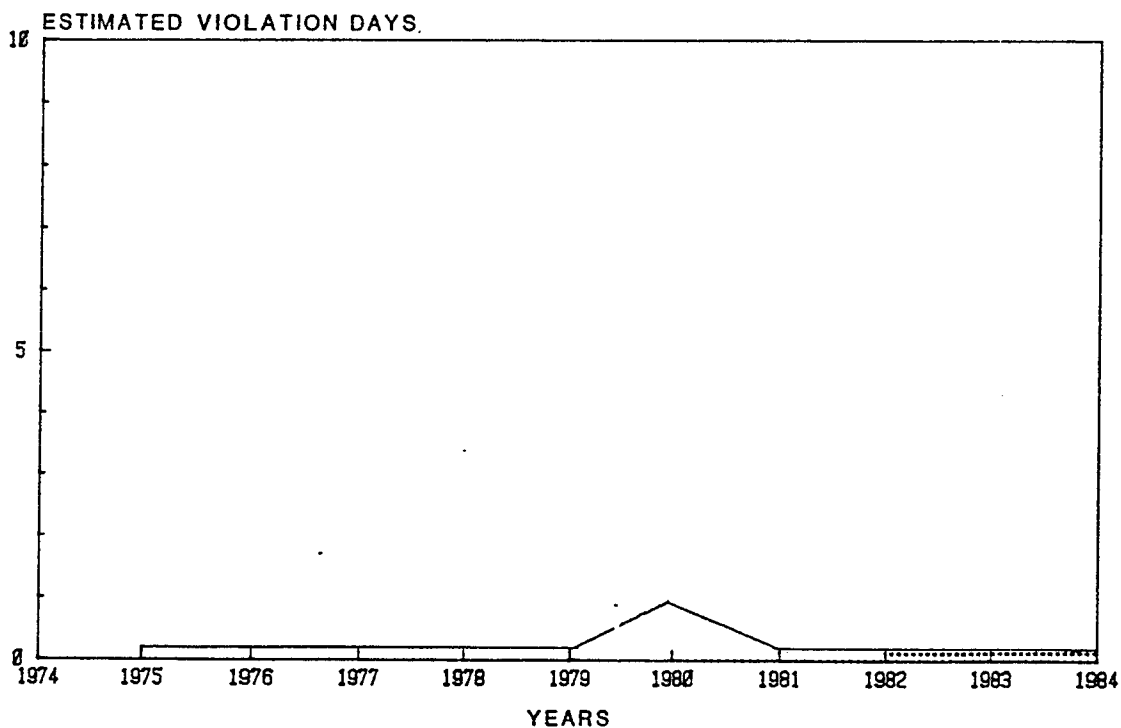
COLORADO
SPRINGS
712 S. Tejon

SECURITY
Academy Blvd.



COLORADO
SPRINGS
712 S. Tejon

SECURITY
Academy Blvd.



4. NITROGEN DIOXIDE (NO₂)

4.1 Description and Sources

In its pure state, nitrogen dioxide is a reddish-orange-brown gas with a characteristic pungent odor. It is corrosive and a strong oxidizing agent. Nitrogen in the air combines with oxygen during high temperature combustion producing oxides of nitrogen (NO_x). Most of the NO_x emitted is nitric oxide (NO). NO₂ is formed, generally, from the oxidation of the more commonly emitted NO. Nitrogen dioxide is the predecessor of gaseous nitric acid and nitrate aerosols. The relationship between NO_x and resulting ambient NO₂, nitric acid and nitrate aerosol concentrations is neither direct nor constant.⁸ (See Figure 3-1). About 48 percent of the emissions of NO_x in the Denver area come from large combustion sources such as power plants, 37 percent from motor vehicles, 11 percent from space heating, and 4 percent from aircraft.⁹

4.2 Health and Welfare Effects

The U.S. EPA has concluded, "While adverse effects have been reported at NO₂ levels above 1.0 ppm, little credible evidence exists that links specific human health effects to NO₂ concentrations at or near ambient levels. However, not to establish a standard, we believe, would ignore the cumulative evidence for animal, controlled human exposure, and community indoor air pollution studies which suggest that NO₂ may cause adverse health effects in sensitive population groups exposed to NO₂ at or near existing ambient levels. NO_x effects on man's environment, personal comfort, and well being include impacts on vegetation, materials, visibility, rates of acidic deposition and symptomatic effects on humans."¹⁰ Table 4-1 contains a summary of nitrogen dioxide health effects experienced at various exposure levels.

4.3 Standards

The current standard for NO₂ is an annual arithmetic mean (average) value not to exceed .053 ppm.⁵ No violations of the NO₂ standard have been recorded in Colorado in seven years .

In 1982, the Air Quality Control Commission, at the request of the City of Denver, reclassified the Denver area as an attainment area for NO₂. This action eliminated the only nonattainment area for NO₂ in Colorado.

4.4 Monitoring

The state operated four continuous chemiluminescence NO₂ monitors in 1984 (see Table 4-2). Table 4-2 contains the 1984 Data Summary for NO₂. Figure 4-1 presents the NO₂ Historical Comparison graphs.

TABLE 4-1

ESTIMATED HEALTH EFFECTS LEVELS FOR NITROGEN DIOXIDE EXPOSURE¹⁰

EFFECTS	EXPOSURE DURATION	
Specific airway resistance increase. Asthmatics reported mild symptomatic effects. Significant decrement in blood gas parameters for both healthy adults and bronchitics; no changes observed below 2.0 PPM. Significant increase in airway resistance at or above 1.6 PPM.	0.1-5.0 PPM	3 minutes to 2-Hours
No physiologically significant changes in cardiovascular, metabolic or pulmonary function after exercise of up to 60 minutes.	0.6 PPM	2-Hours
Increased inspiratory and expiratory flow resistance. No statistically significant changes in healthy adults pulmonary function tests with the exception of small changes in forced vital capacity. Slight increase in respiratory symptoms above 2.0 PPM.	1.0-2.0 PPM	2-Hours

TABLE 4-2

NITROGEN DIOXIDE (NO₂)

1984 DATA SUMMARY
(parts per million)

Standard = 0.053 ppm

<u>SITE</u>	<u>LOCATION</u>	<u>DAYS MONITORED</u>	<u>ANNUAL AVERAGE</u>
3-Y	Aurora, 50 S. Peoria	292	0.017
3-J	Denver (CAMP), Broadway & 21st St.	295	0.047
3-W	Welby, 78th & Steele	255	0.023
4-A	Colorado Springs, 712 S. Tejon	355	0.029

FIGURE 4-1

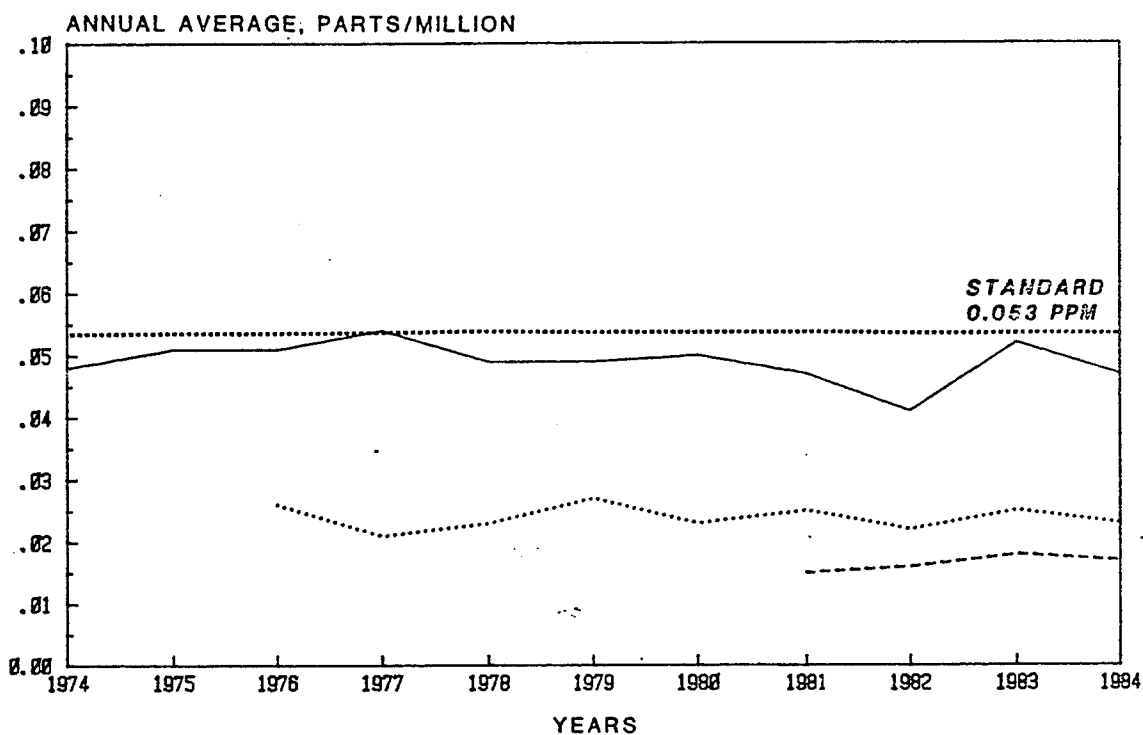
NITROGEN DIOXIDE
HISTORICAL COMPARISONS

AQCR #3

DENVER, CAMP
21st & Broadway

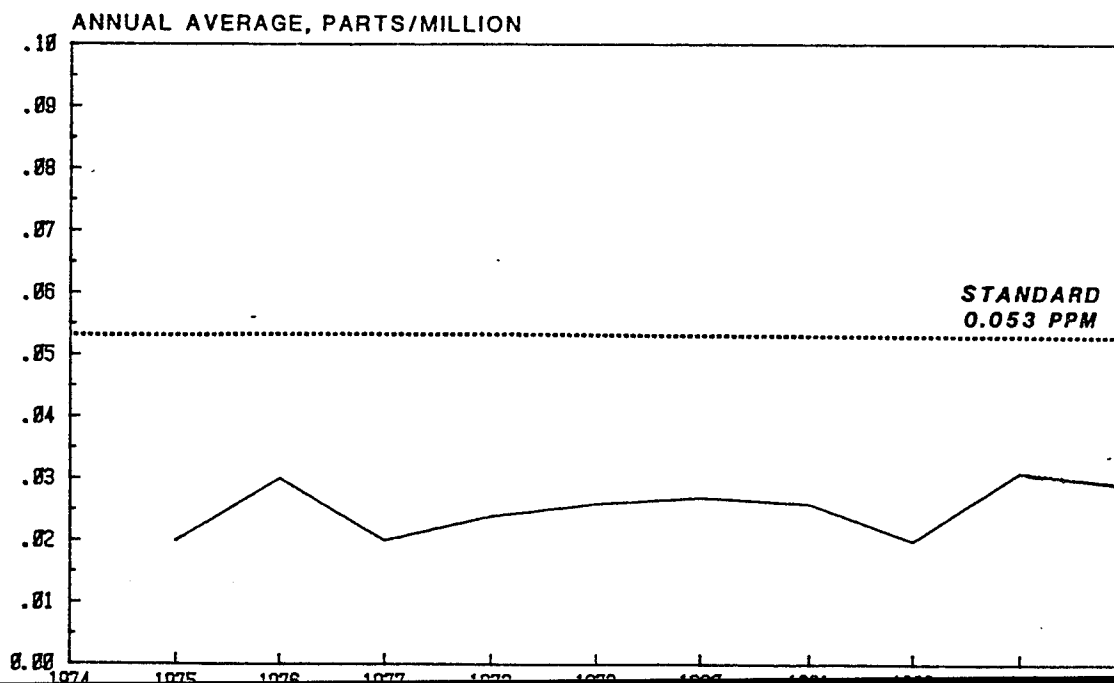
AURORA
50 S. Peoria

WELBY
72nd & Steele



AQCR #4

COLORADO SPRINGS
712 S. Tejon



5. SULFUR DIOXIDE(SO₂)

5.1 Description and Sources

Sulfur dioxide is a colorless gas with a pungent odor detectable at concentrations of about 0.5 to 0.8 ppm.¹¹ Sulfur dioxide is highly soluble in water, resulting in the formation of sulfurous acid. On a worldwide basis, SO₂ is considered to be one of the major pollution problems. It is emitted mainly from stationary sources that burn fossil fuels (coal, oil) such as power plants and refineries, or in the production of materials from sulfur bearing ores, such as copper smelting. It is also emitted in significant amounts from natural sources such as volcanic eruptions. However, these sources rarely play an important role in the urban sulfur dioxide problem.

5.2 Health and Welfare Effects

The health effects of sulfur dioxide appear to frequently be associated with high levels of particulates or other pollutants. The world's major recorded air pollution disasters have been associated with high levels of sulfur dioxide and particulates.¹² The excess deaths attributed to these pollutants were due to respiratory failures and occurred predominantly, but not exclusively, in the elderly and infirm.

Sulfur dioxide is also converted in the atmosphere to sulfuric acid aerosols and particulate sulfate compounds which are corrosive and potentially carcinogenic (cancer causing). These are part of the problem known as "acid rain". In Eastern areas of the country where greater emission levels of sulfur compounds exist, concern has been raised that sulfur dioxide and acid rain may be adversely affecting the environment due to crop and forest damage, fish losses in lakes and decline in the quality of drinking water.¹³ Table 5-1 contains a summary of sulfur dioxide health effects experienced at various exposure levels.

5.3 Standards

There are two existing Primary National Ambient Air Quality Standards for sulfur dioxide. The first is a long-term one year arithmetic average of 0.03 parts per million (ppm). The second is a short-term 24-hour average standard where concentrations are not to exceed 0.14 ppm more than once per year.⁵ The current Secondary NAAQS for SO₂ is a 3-hour average concentration of 0.5 ppm not to be exceeded more than once per year.³⁰

Colorado currently has no areas which violate or have violated the NAAQS for sulfur dioxide. However, due to the long range transport of sulfate aerosols and potential development of oil shale areas, concern over visibility and acid rain exists in Colorado.

5.4 Monitoring

The State operated two and assisted in the operation of a third SO₂ monitor in 1984 (see Table 5-2) using continuous pulsed fluorescence analyzers.

Table 5-2 is the 1984 Data Summary for SO₂. Figure 5-1 presents the SO₂ Historical Comparison graphs.

TABLE 5-1

ESTIMATED HEALTH EFFECTS LEVELS FOR SULFUR DIOXIDE EXPOSURE¹⁶

EFFECTS	EXPOSURE DURATION	
Pulse and respiratory rate increase, tidal volume rate decrease, airway conductance decrease, decreased peak flow above 1.6 PPM and bronchoconstriction above 5.0 PPM.	1.0-10.0 PPM	10 minutes
Mucociliary activity decreased at 15 PPM, and increased airway resistance.	10.0-60.0 PPM	10-60 Minutes

TABLE 5-2

SULFUR DIOXIDE (SO₂)

1984 DATA SUMMARY
(parts per million)

Standard =

3-hour = 0.5 ppm
24-hour = 0.14 ppm
Annual = 0.03 ppm

<u>SITE</u>	<u>LOCATION</u>	<u>DAYS MONITORED</u>	<u>3-HOUR SECOND HIGHEST</u>	<u>24-HOUR SECOND HIGHEST</u>	<u>ANNUAL AVERAGE</u>
3-J	Denver (CAMP), Broadway & 21st St	353	0.09	0.04	0.011
3-W	Welby, 78th & Steele	355	0.06	0.02	0.007
11-F	Grand Junction, 711 Independent	289	0.03	0.01	0.005

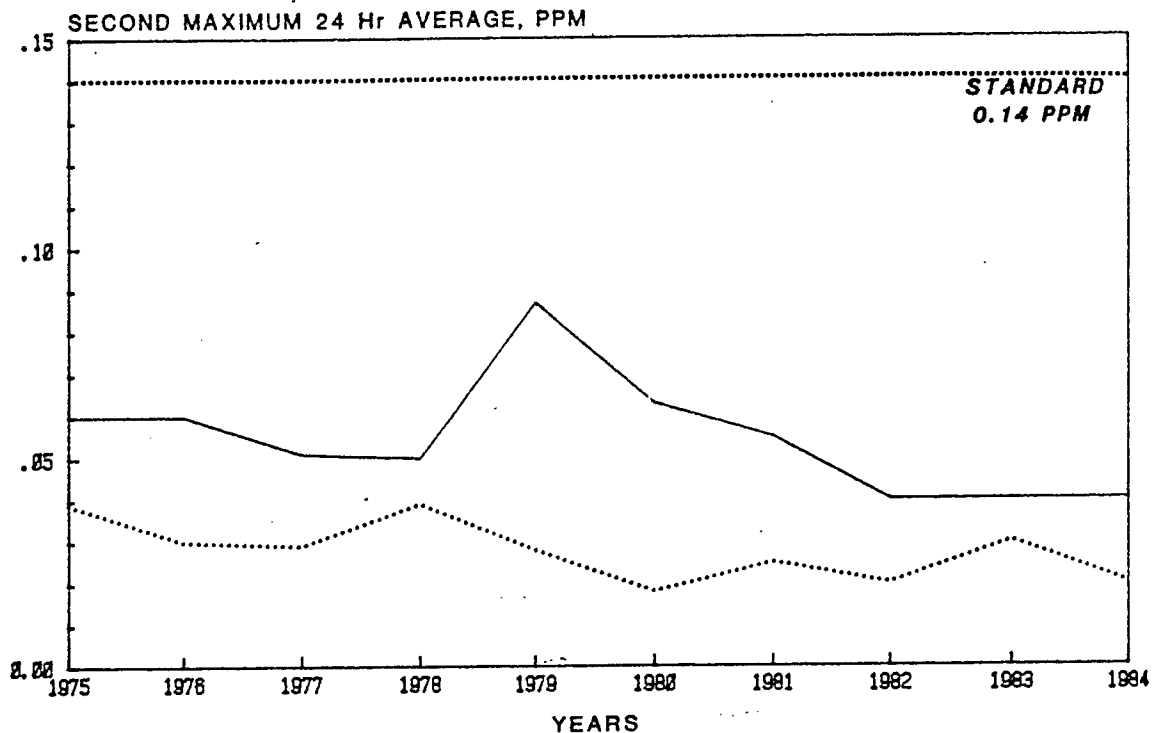
FIGURE 5-1

SULFUR DIOXIDE
HISTORICAL COMPARISONS

AQCR #3

DENVER, CAMP
21st & Broadway

WELBY
72nd & Steele



DENVER, CAMP
21st & Broadway

WELBY
72nd & Steele

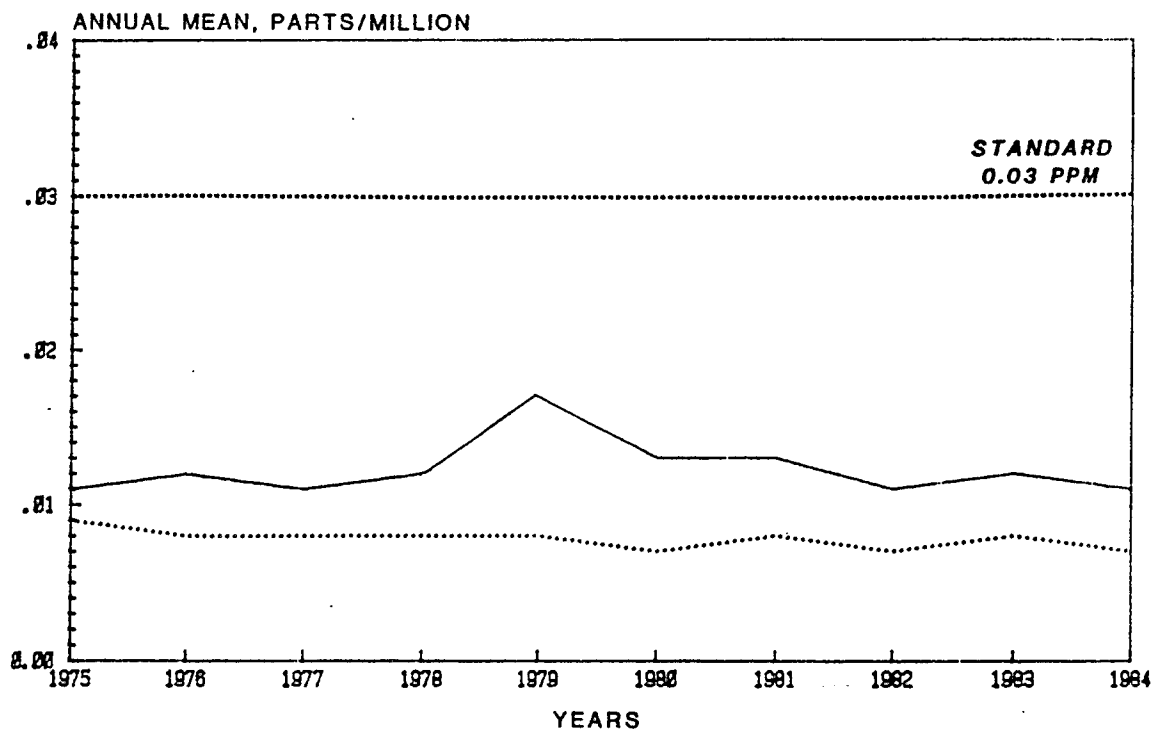
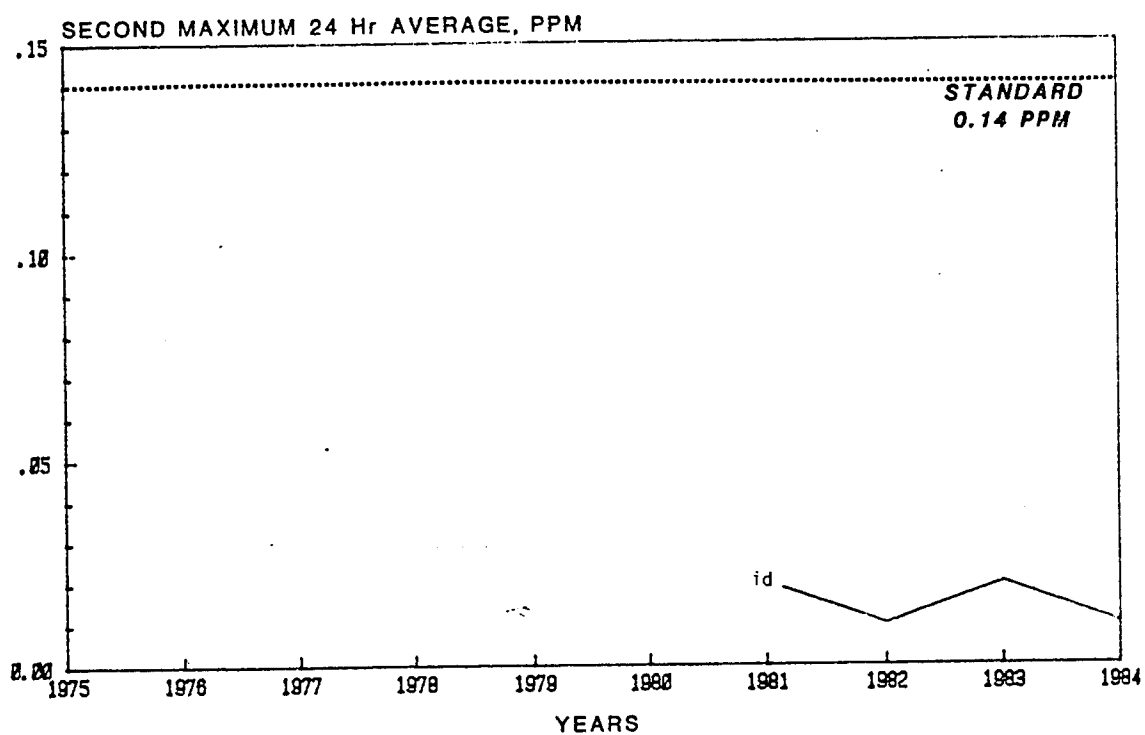


FIGURE 5-1

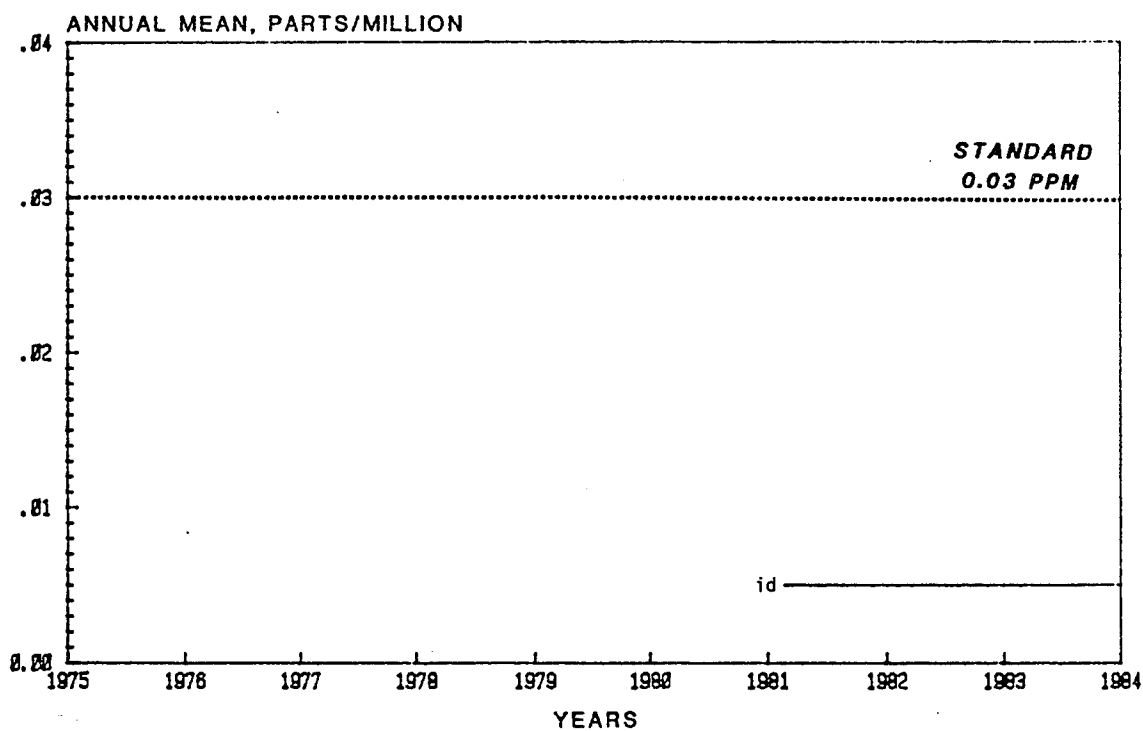
SULFUR DIOXIDE
HISTORICAL COMPARISONS

AQCR #11

GRAND JUNCTION
711 Independent



GRAND JUNCTION
711 Independent



6. PARTICULATE MATTER

6.1 Description and Sources

Particulate matter is the term given to the tiny particles of solid or semi-solid material found in the atmosphere. These particles in the atmosphere are a major contribution to the visibility-related problems in both urban and rural areas. In Denver this is commonly known as the "Brown Cloud," or more appropriately the "Denver Haze" because it is frequently not brown nor is it actually a cloud. The sources of particulates are many: wind-blown dust and sand from roadways, fields, and construction; coal dust, fly ash, and carbon black from various combustion sources including automobile exhaust, to name a few. Two increasing sources of particulates that could have a major impact on haze problems are diesel automobiles and wood stoves. These sources emit potentially significant amounts of elemental and organic carbon particles that play a major role in haze phenomena and health effects. Particulates that range in size from less than 0.1 micrometer to fifty of micrometers are called "Total Suspended Particulates (TSP)". Particles larger than that range tend to settle out of the air and do not generally remain suspended.

6.2 Health and Welfare Effects

Particles inhaled by humans are size segregated during deposition within the respiratory system. Larger particles deposit in the upper respiratory tract, while smaller, "inhalable" particulates travel deeper into the lungs. The major regions of the respiratory system differ widely in structure, size, function, sensitivity, or reactivity to deposited particles and to the mechanism of particle elimination from the system.¹⁴

Toxicity of particles retained in the lungs varies with chemical composition. Some chemicals such as sulfuric acid may react directly with the system, while others may act to retard clearance of other particles from the lung. Particulates may also act as carriers for gaseous pollutants and can cause synergistic effects, such as when sulfur dioxide and particulate exposures occur simultaneously. Carbon particles are the most common carrier for gaseous pollutants.

The route of toxicity due to particulate exposure may not be directly through the respiratory system, but may allow for the collection of materials and subsequent entrance to the stomach in swallowed mucus. Such a mechanism is the primary route for lead exposures due to atmospheric lead.¹⁵

The welfare effects of particulate exposure may be the most wide spread of all the pollutants. Because of the potential for extremely long range transport for fine particles and chemical reactions that occur, no place on earth has been spared from the particulates generated by urban and rural sources. Acid deposition (acid rain) can be detected in the most remote areas of the world. The effects of particulates range from visibility degradation to climate changes to vegetation damage. General soiling, commonly thought to be just a nuisance, can have long term effects on building paints and other materials.¹⁶ Due to the complex nature of particulate matter composition, general health effects are not presented tabularly for particulates. Specific examples of effects of particulate components such as lead and sulfates are displayed in their separate chapters.

6.3 Standards

Primary:

The current primary particulate matter standards are for total suspended particulates (TSP), independent of particle size or chemical composition. The long-term standard is an annual geometric mean not to exceed 75 micrograms of particulates per cubic meter of air (ug/m^3). The short-term standard is a 24-hour average of $260 \text{ ug}/\text{m}^3$ not to be exceeded more than once per year.⁵

EPA is considering revising the particulate standards to account for the deeper inhalability of smaller particles. The new standards, rather than applying to TSP, would apply to particles less than 10 micrometers in diameter. As of the production of this document, EPA is proposing the primary standard to be an annual arithmetic average in the range of $50\text{--}65 \text{ ug}/\text{m}^3$ and the 24-hour value to be between $150\text{--}250 \text{ ug}/\text{m}^3$.

Secondary:

The current secondary TSP standard is a 24-hour average of $150 \text{ ug}/\text{m}^3$ not to be exceeded more than once per year⁵, designed to protect from soiling, corrosion, etc.

EPA is also considering a total particulate secondary standard designed to protect visibility in the range of $70\text{--}90 \text{ ug}/\text{m}^3$ annual mean.

6.4 Monitoring

The state operated High-Volume Particulate Samplers at 72 sites in 1984 (see Table 6-1).

These High-Volume Samplers, or Hi-Vols, operate on the same principle as a vacuum cleaner. Air is drawn through a filter to "catch the dust". The difference is that a Hi-Vol draws a calibrated volume of air through a pre-weighed filter pad (rather than a bag) for a twenty-four hour period every fourth day. The change in weight of the filter pad is recorded as Total Suspended Particulate (TSP) in micrograms of particulates per cubic meter of air sampled.

Table 6-1 is the 1984 Data Summary for TSP. Figure 6-1 presents the TSP Historical Comparison graphs. Certain samplers, called Size Selective Hi-Vols, are designed to collect only particles smaller than a given size (currently 15 micrometers). As mentioned above, these smaller particles are more closely related to inhalable particulates. PM_{15} data are collected from eight sites by the State (see Table 1-2). Table 6-1 contains the 1984 Data Summary for PM_{15} .

TABLE 6-1

TOTAL SUSPENDED PARTICULATES (TSP)

1984 DATA SUMMARY
(micrograms per cubic meter)

SITE	LOCATION	Days Sampled	TSP			PM15			SULFATES			NITRATES			LEAD	
			Ann.	Geo.	Avg.	2nd Max.	Ann.	Arit.	2nd Avg.	Arit.	Max.	Ann.	Arit.	2nd Max.	Max.	Qtr.
1-A	Brush	86	56	121					3.2	10.6		15.6	6.9			
1-B	Fort Morgan	85	54	124												
1-C	Sterling	74	64	176												
2-A	Estes Park	83	37	88												
2-B	Fort Collins	85	55	148			41	104	3.4	10.8		3.8	13.5			
2-D	Greeley, 6th&10th	69	48	265					2.9	7.8		3.7	22.7			
2-E	Greeley, Hosp.Rd.	88	52	178												
2-F	Loveland	85	62	203												
2-G	Platteville	85	67	210												
3-A	Adams City	87	97	263					5.8	10.7		5.5	16.9		0.7	
3-B	Arvada	79	90	298												
3-C	Aurora	88	69	217												
3-D	Boulder	79	60	185												
3-E	Brighton	84	80	266												
3-G	Castle Rock	85	79	189												
3-I	Denver, 414	83	101	275											0.4	
3-II	Denver, 414*	90	93	258												
3-J	Denver (CAMP)	99	142	522					6.4	11.7		5.1	14.9		0.9	
3-K	Denver, Gates	84	102	306												
3-L	Denver, (CDH)	84	72	166			49	108							0.8	
3-P	Englewood	81	94	203												
3-Q	Golden	77	77	535												
3-R	Highlands	87	55	162					4.6	11.3						
3-S	Lakewood	74	75	187												
3-T	Longmont	85	81	247												

+ This site is not shown graphically since it has less than 3-years of data.

TABLE 6-1 (Continued)

TOTAL SUSPENDED PARTICULATES (TSP)

1984 DATA SUMMARY
(micrograms per cubic meter)

SITE	LOCATION	Days Sampled	TSP			PM15			SULFATES			NITRATES			LEAD	
			Ann.	Geo.	2nd Avg.	Ann.	Arit.	2nd Avg.	Ann.	Arit.	2nd Avg.	Ann.	Arit.	2nd Avg.	Max.	Qtr.
3-U	Rocky Flats	71	76	246												
3-V	Westminster	87	87	276												
4-D	Colo. Spgs, Foote	83	56	163	31	113			3.4	6.3		2.5	6.7		0.4	
4-E	Colo. Spgs, Mdln.	85	75	320												
4-F	Colo. Spgs, Cscd.	72	73	221												
4-F1	Colo. Spgs, Cscd.*	78	70	154												
5-A	Limon	83	33	110												
6-A	La Junta	87	55	118												
6-B	Lamar	80	75	246												
7-A	Pueblo, Cent. Main	85	75	193	27	126									0.4	
7-B	Pueblo, Mesa/Evans	86	64	171												
7-C	Pueblo, Watts Sta.	82	36	90												
7-E	Pueblo, Airport	79	34	118	28	73										
7-F	Pueblo, W. 17th.	83	47	113												
7-G	Pueblo, South Dump	73	22	68												
7-D	Trinidad	85	48	113												
8-A	Alamosa	81	52	146												

+ This site not shown graphically since it has less than 3 years of data.

TABLE 6-1 (Continued)

TOTAL SUSPENDED PARTICULATES (TSP)

1984 DATA SUMMARY

(micrograms per cubic meter)

SITE	LOCATION	TSP			PM15			SULFATES			NITRATES			LEAD	
		Days Sampled	Ann. Geo.	2nd Avg.	Ann. Arit.	2nd Avg.	Max.	Ann. Arit.	2nd Avg.	Max.	Ann. Arit.	2nd Avg.	Max.	Max. Qtr.	
9-B	Durango	86		64		211									
9-C	Mesa Verde	(67)		(11)		(41)									
9-D	Pagosa Springs	85		114		395									
								(2.5)	(4.8)		(1.0)	(3.9)		0.0	
10-A	Crested Butte	81		71		191									
10-B	Delta	84		71		224									
10-E	Montrose	88		54		148									
10-F	Telluride	88		81		205								0.2	
11-A	Craig	74		62		143		45		102					
11-B	Fruita	80		44		99		35		92					
11-C	Glenwood Springs														
	8th & Colo.	(8)		(78)		(109)									
11-D	Grand Junction,														
	5 th & Rood	80		63		149		47		127					
11-E	Grand Junction,														
	12th & North	81		53		141									
11-G	Palisade	85		38		84									
11-H	Meeker	78		39		96									
11-I	Parachute	(35)		(25)		(95)									
11-J	Rangley	(58)		(57)		(128)									
11-K	Rifle	85		32		114									
11-L	Glenwood,														
	806 Cooper	85		65		257									
11-M	Colo Nat'l Mont., Mesa	74		12		47									
								2.9	5.7		1.2	3.8			

TABLE 6-1 (Continued)

TOTAL SUSPENDED PARTICULATES (TSP)

1984 DATA SUMMARY
(micrograms per cubic meter)

SITE	LOCATION	TSP			PM15			SULFATES		NITRATES		LEAD	
		Days Sampled	Ann. Geo.	2nd Avg.	Ann. Arit.	2nd Avg.	Max.	Ann. Arit.	2nd Avg.	Ann. Arit.	2nd Avg.	Max. Qtr.	Max. Qtr.
12-A	Aspen, Ct. House	(65)	(63)	(242)								0.3	
12-B	Steamboat Springs	79	74	279								0.2	
12-C	Vail, Med. Bldg.	(64)	(70)	(296)									
12-D	Vail, Frontage Rd.	(67)	(83)	(229)									
12-E	Avon	(56)	(50)	(144)									
12-F	Aspen, Redstone	(18)	(40)	(82)									
12-G	Aspen, Cap. Creek	(44)	(10)	(27)									
12-H	Aspen, Snowmass	70	35	73									
12-I	Aspen, Smuggler	(13)	(35)	(86)									
13-A	Canon City	84	56	291				4.0	8.2	1.8	4.9		
13-C	Leadville	73	57	147								+0.4	

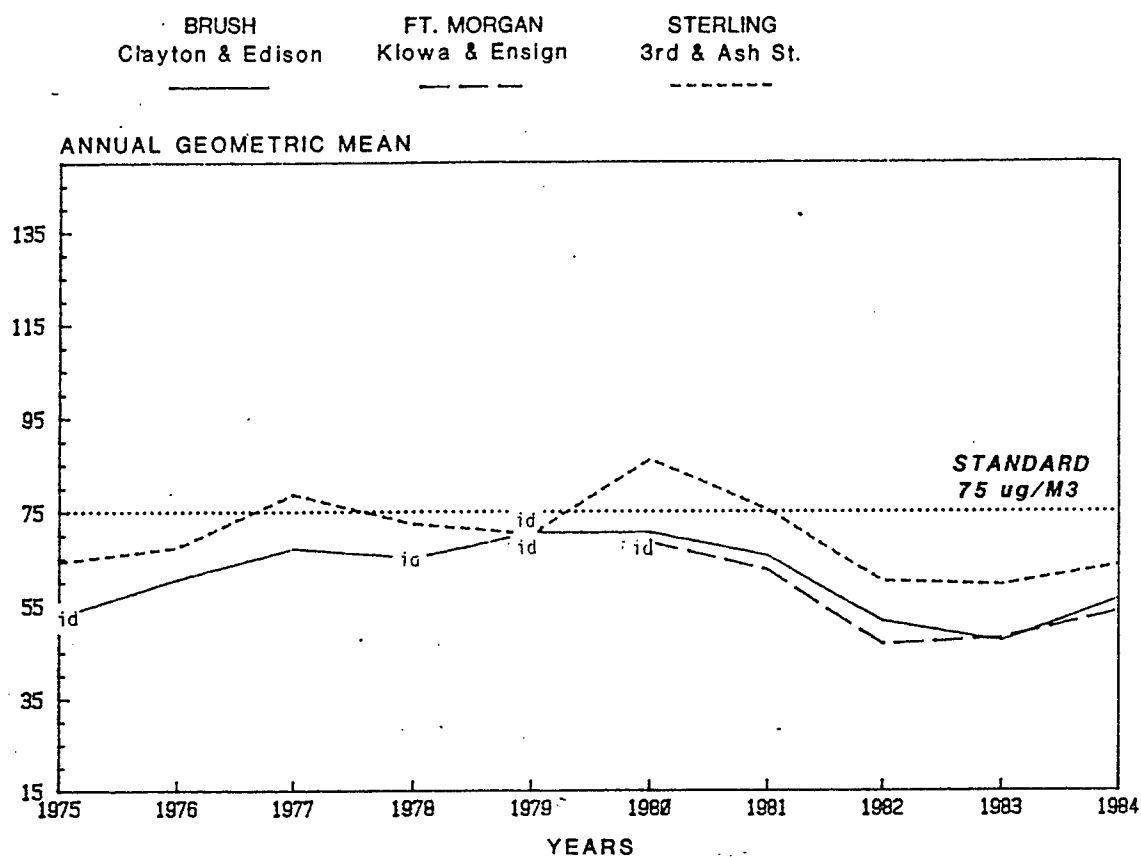
* Collocated Samplers for quality assurance purposes.

+ These sites have less than 3 years of data.

FIGURE 6-1

TOTAL SUSPENDED PARTICULATES
HISTORICAL COMPARISONS

AQCR #1



AQCR #2-LARIMER

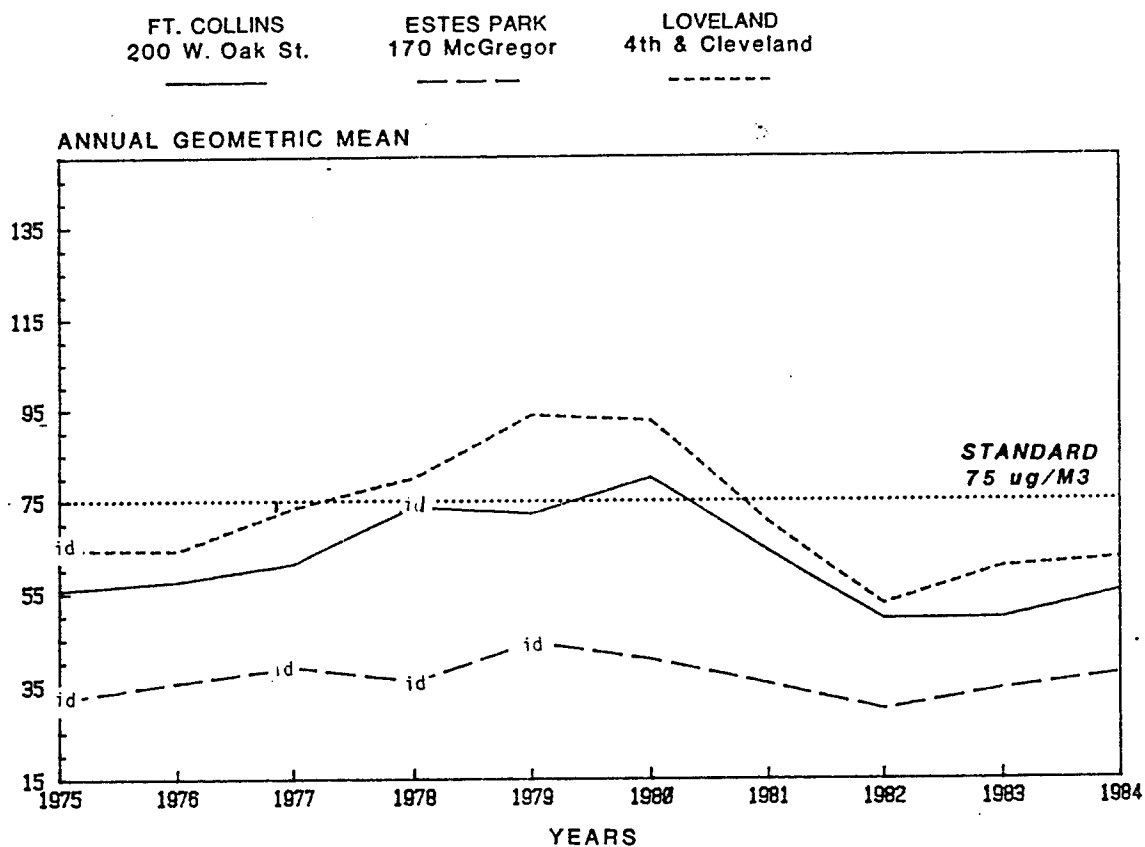
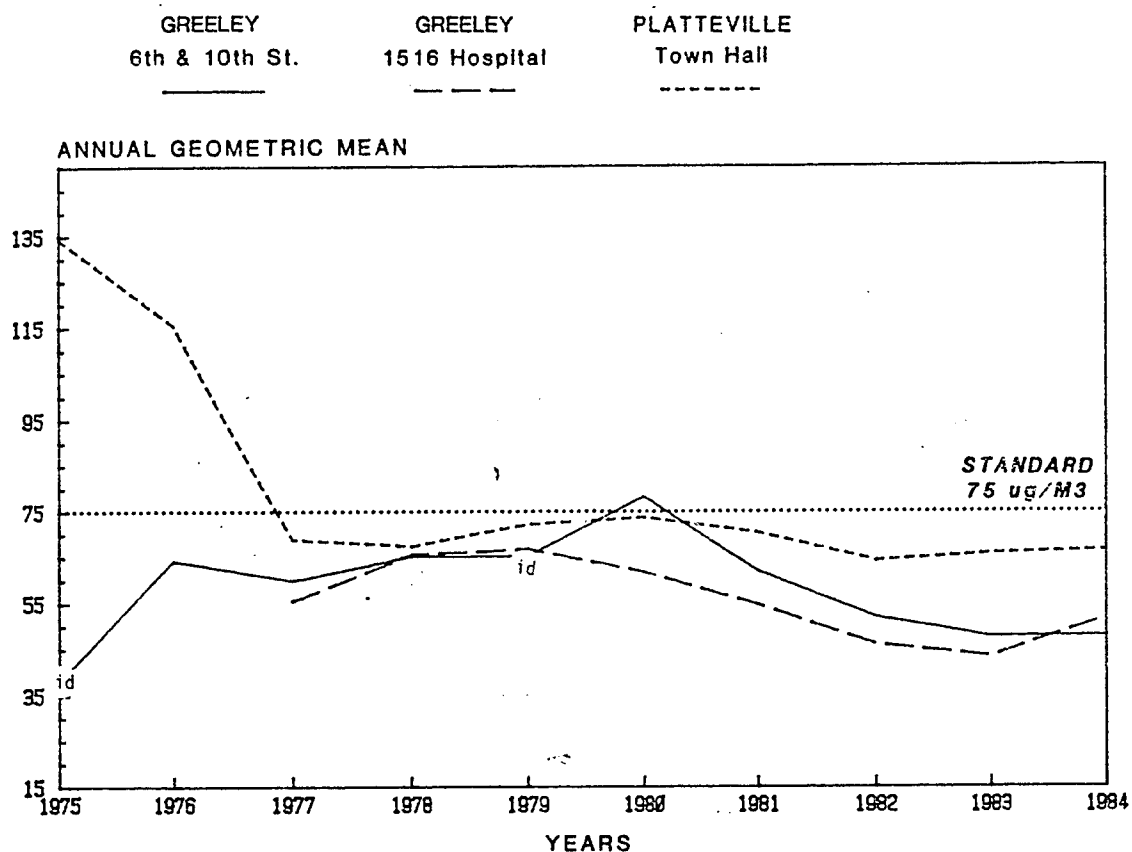


FIGURE 6-1

TOTAL SUSPENDED PARTICULATES
HISTORICAL COMPARISONS

AQCR #2-WELD



AQCR #3-ADAMS

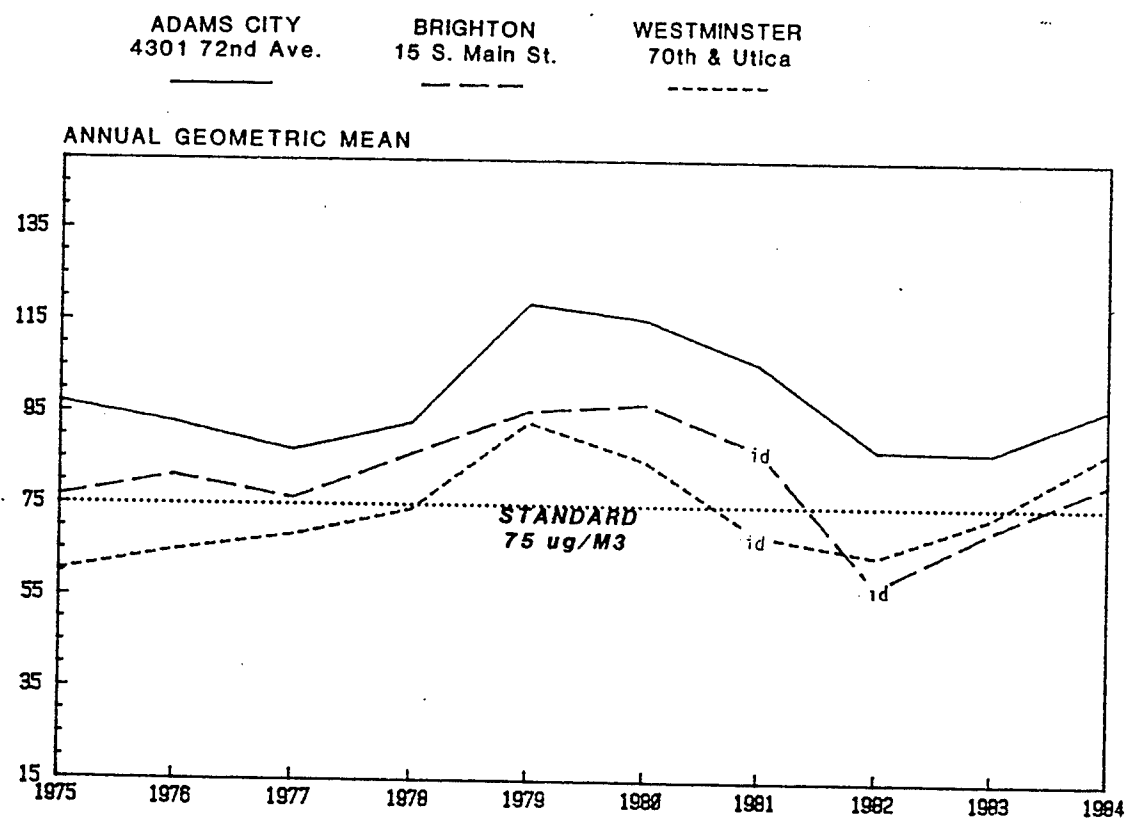


FIGURE 6-1

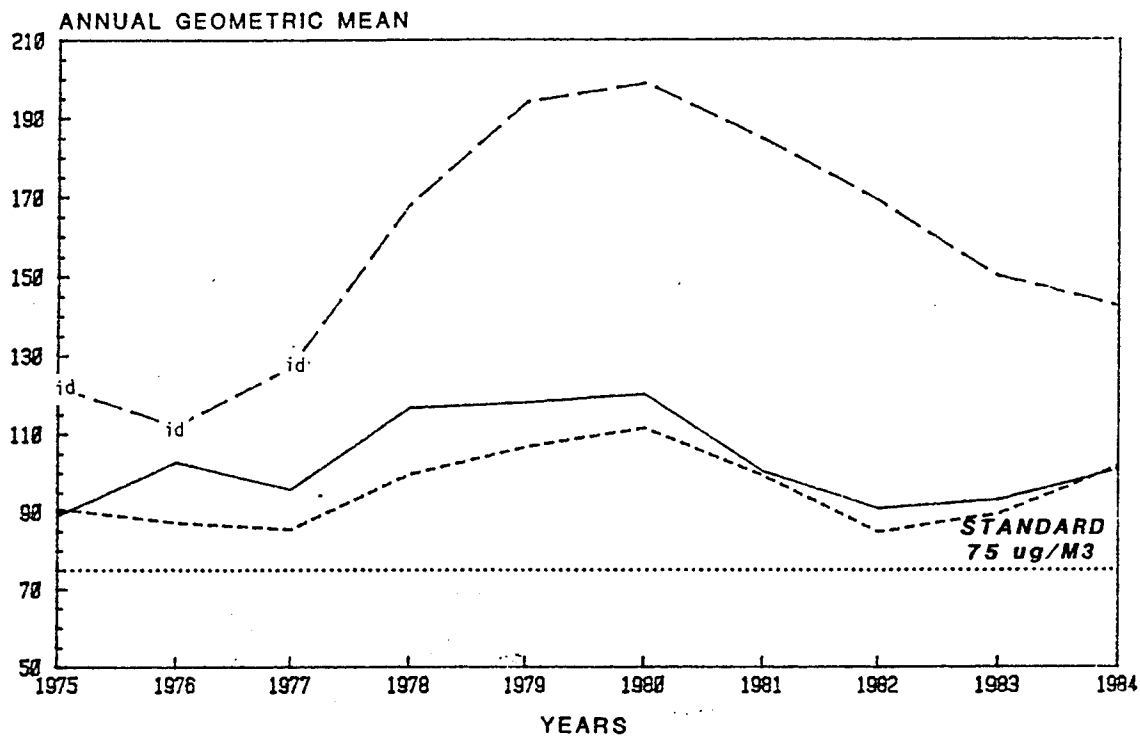
TOTAL SUSPENDED PARTICULATES
HISTORICAL COMPARISONS

AQCR #3-CENTRAL

DENVER
414 14th St.

DENVER,CAMP
21st & Broadway

DENVER,GATES
1050 S. Broadway



AQCR #3-DENVER EAST

DENVER,HLTH
4210 11th Ave.

AURORA
1633 Florence

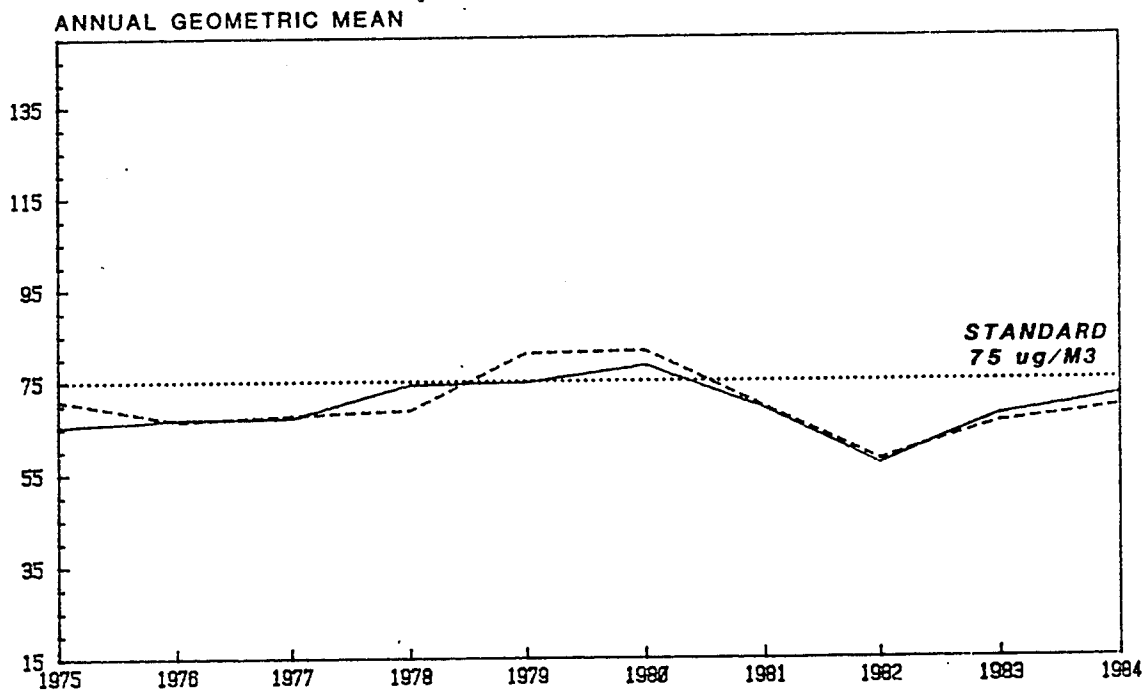
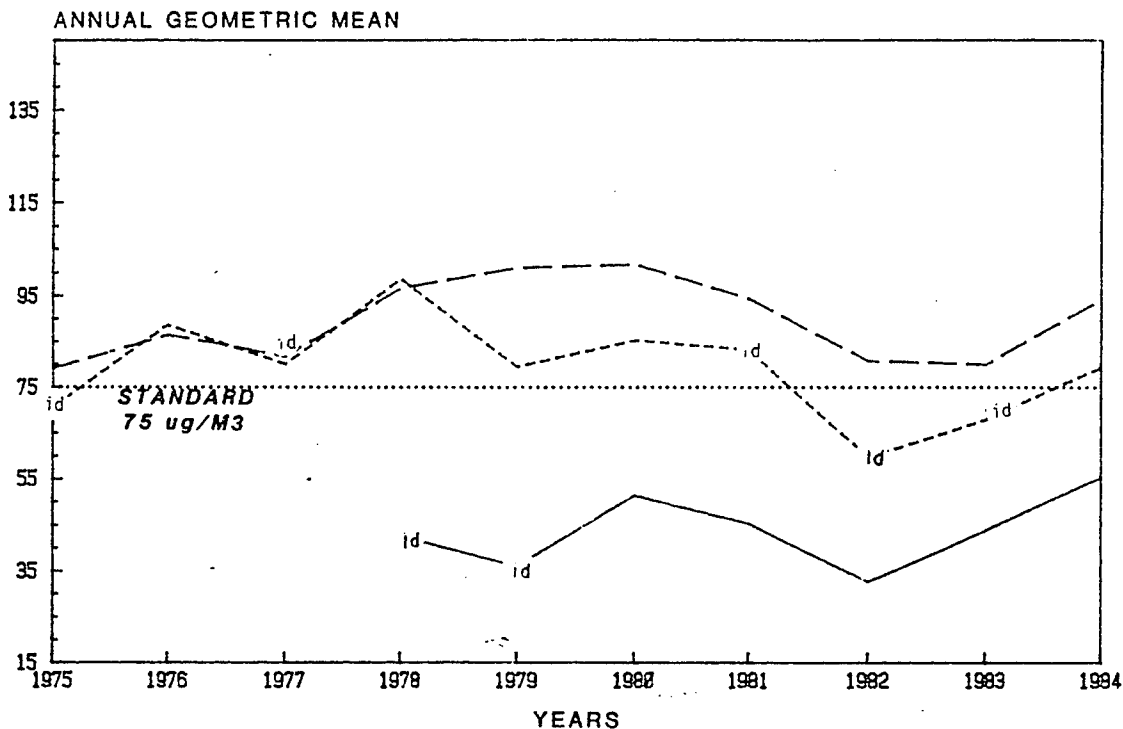


FIGURE 6-1

TOTAL SUSPENDED PARTICULATES
HISTORICAL COMPARISONS

AQCR #3-ARAPAHOE/DOUGLAS

HIGHLAND	ENGLEWOOD	CASTLE ROCK
RESERVOIR	4857 S. Broadway	310 3rd St.
8100 S. University		



AQCR #3-JEFFERSON

ARVADA	GOLDEN	ROCKY FLATS	LAKEWOOD
8101 W. Ralston	911 10th Ave.	Plant Entrance	260 S. Kipling

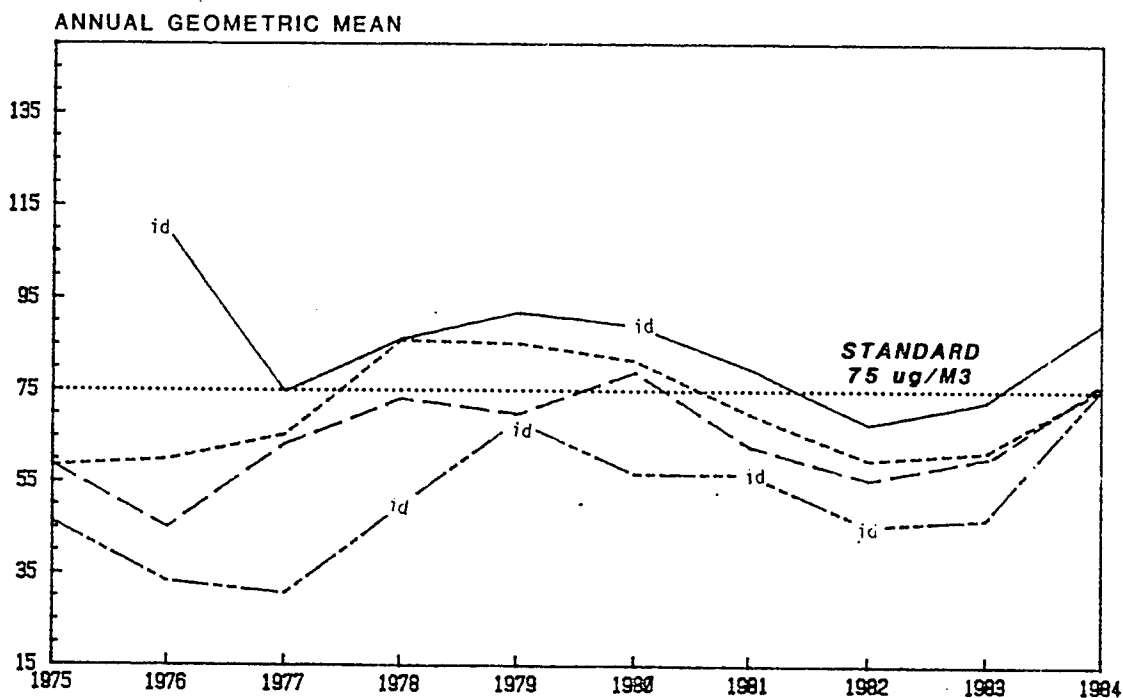
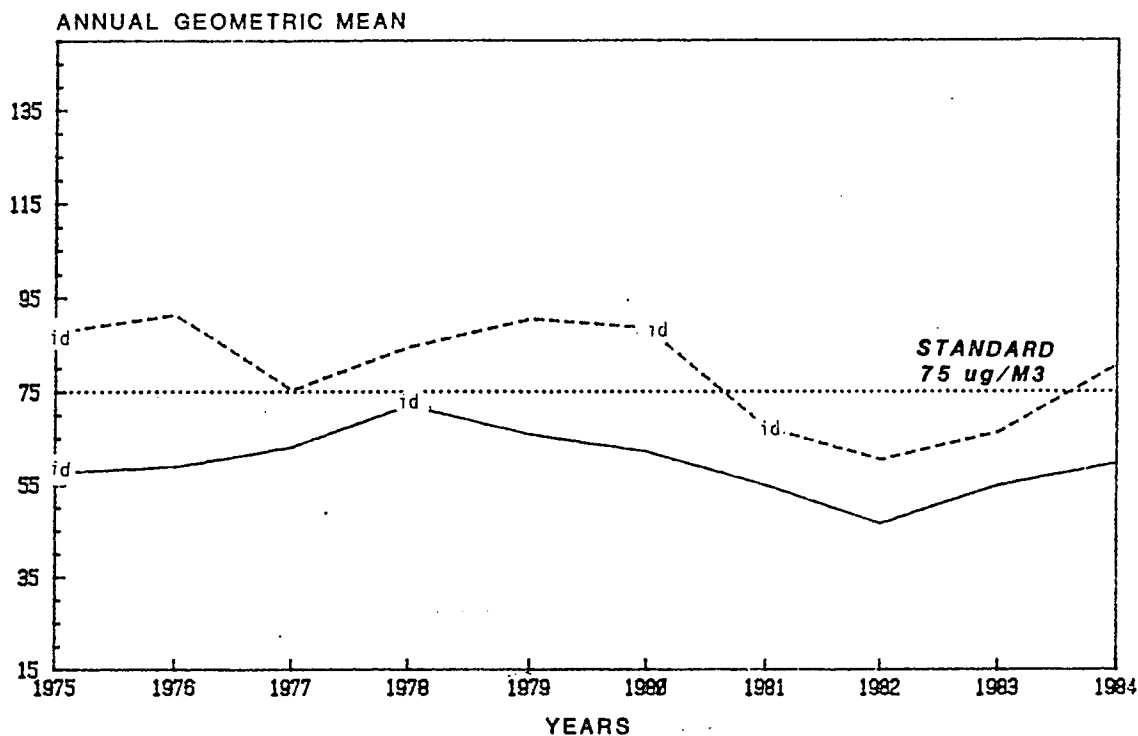


FIGURE 5-1

TOTAL SUSPENDED PARTICULATES
HISTORICAL COMPARISONS

AQCR #3-BOULDER

BOULDER LONGMONT
Hall of Justice City Hall



AQCR #4

COLORADO COLORADO COLORADO
SPRINGS SPRINGS SPRINGS
501 N. Foote 3730 Meadowlands 200 S. Cascade

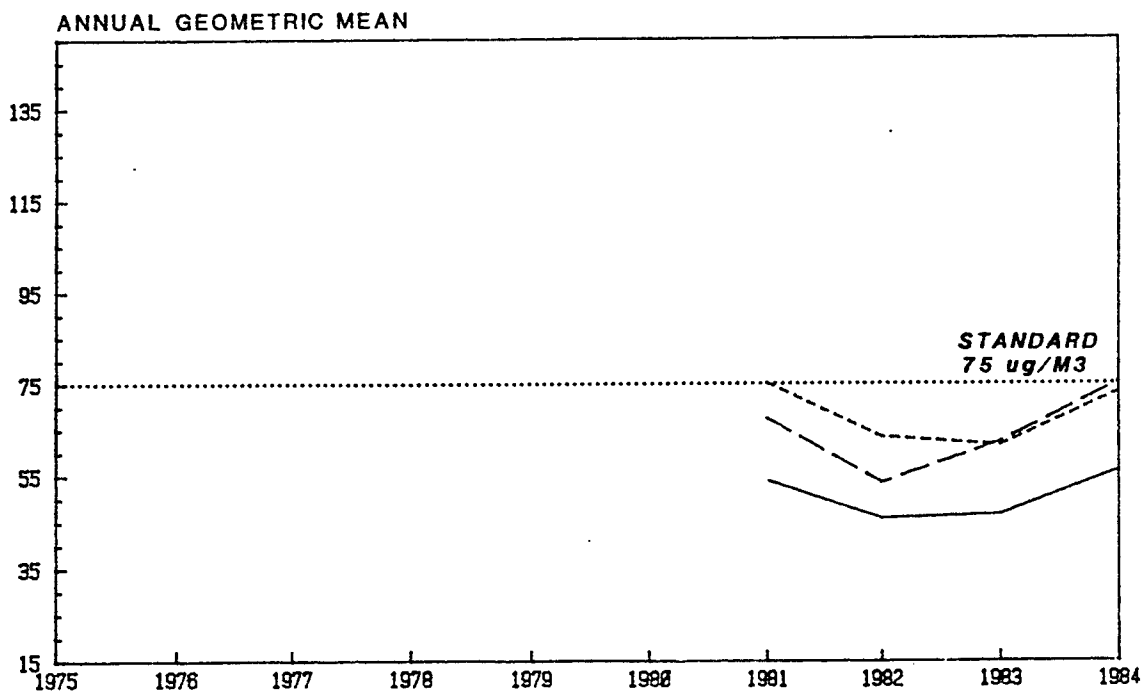
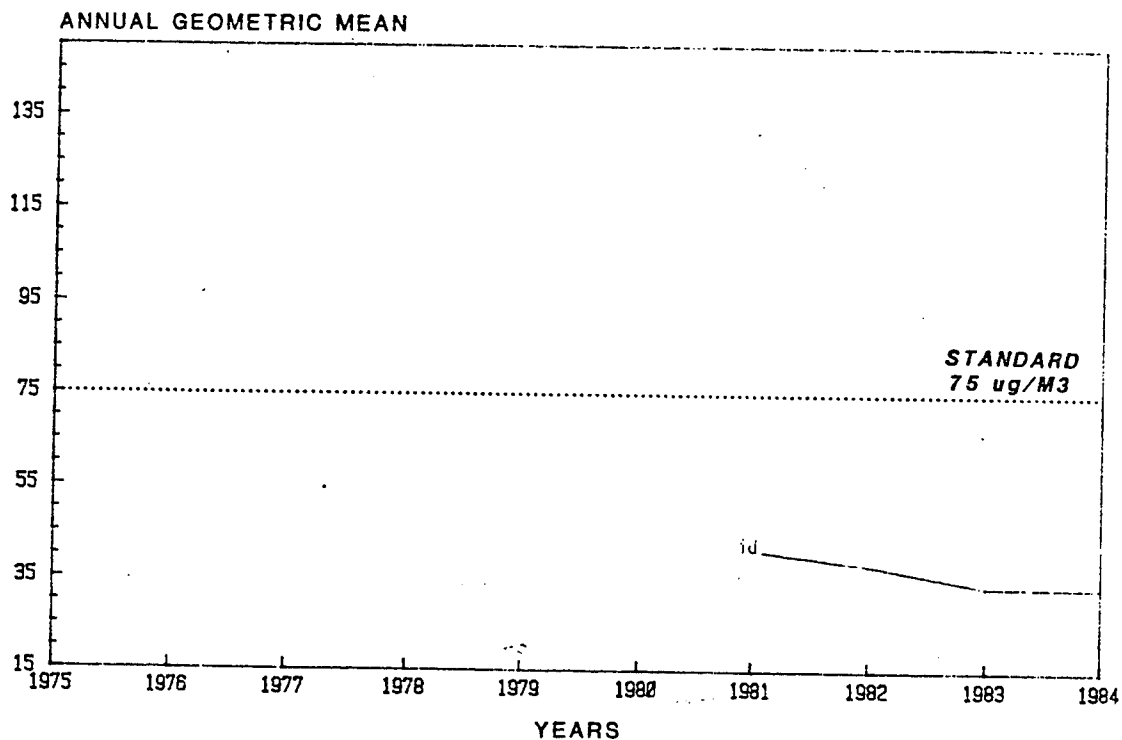


FIGURE 6-1

TOTAL SUSPENDED PARTICULATES
HISTORICAL COMPARISONS

AQCR #5

LIMON
874 F St.



AQCR #6

LA JUNTA
Colorado & 2nd

LAMAR
Power Plant

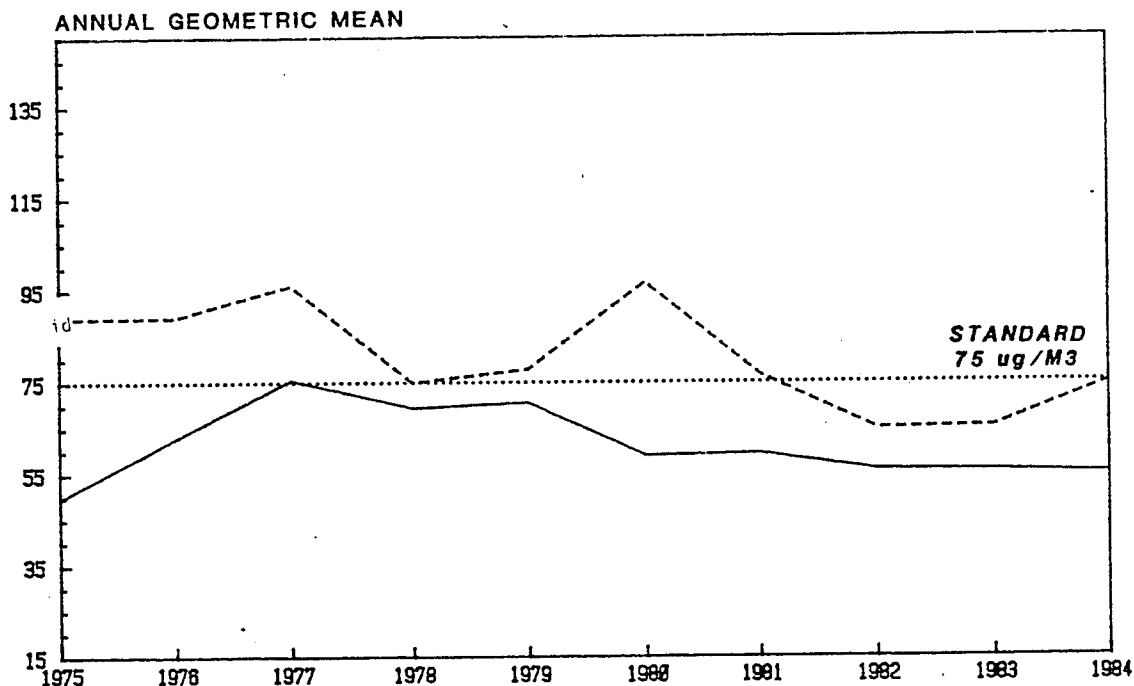
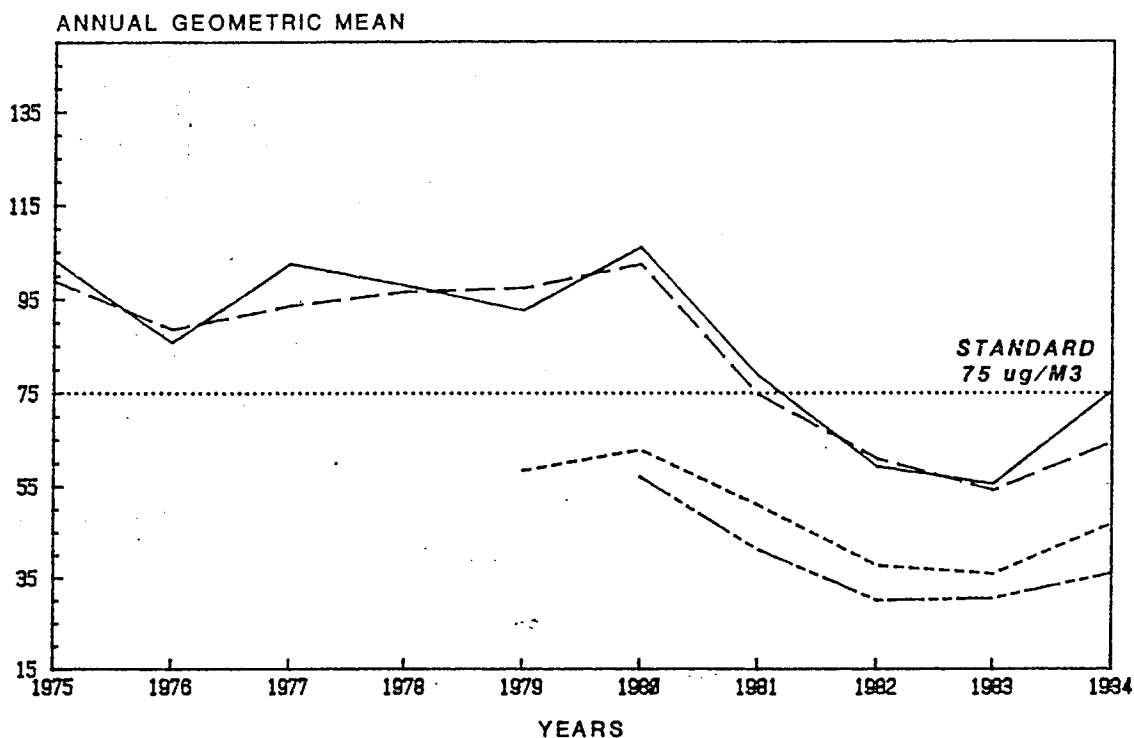


FIGURE 6-1

TOTAL SUSPENDED PARTICULATES
HISTORICAL COMPARISONS

AQCR #7

PUEBLO PUEBLO PUEBLO PUEBLO
Health Dept. Mesa & Evans Watts 17th &
 Pump Station Greenwood Ave.



AQCR #7

TRINIDAD
235 Convent

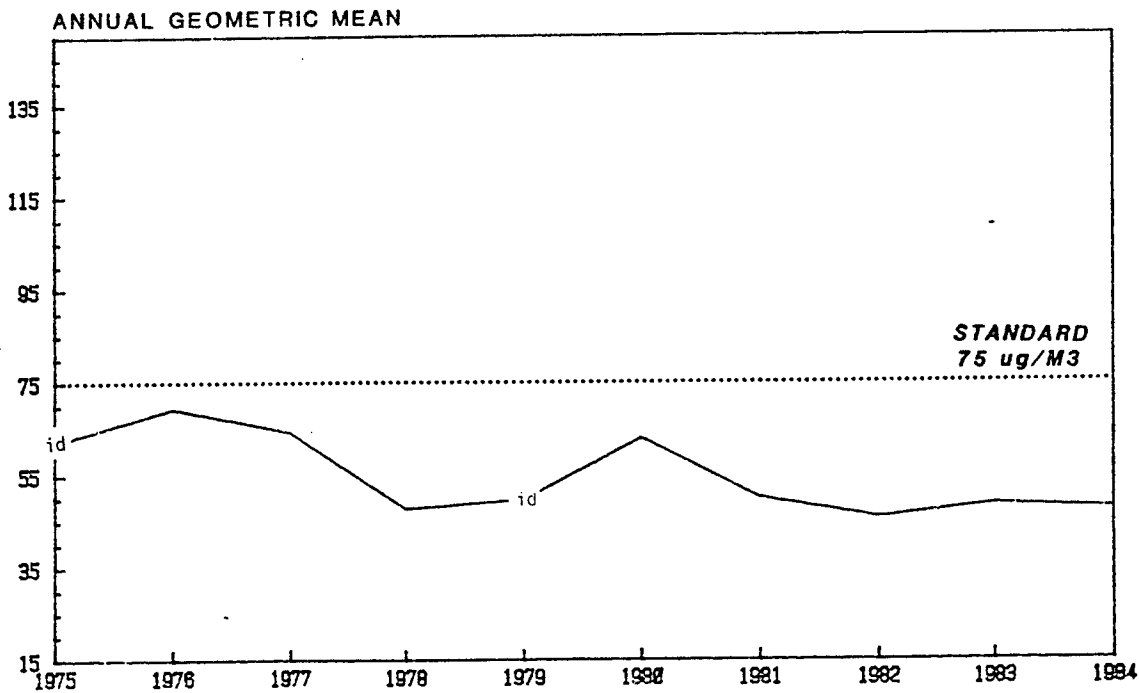
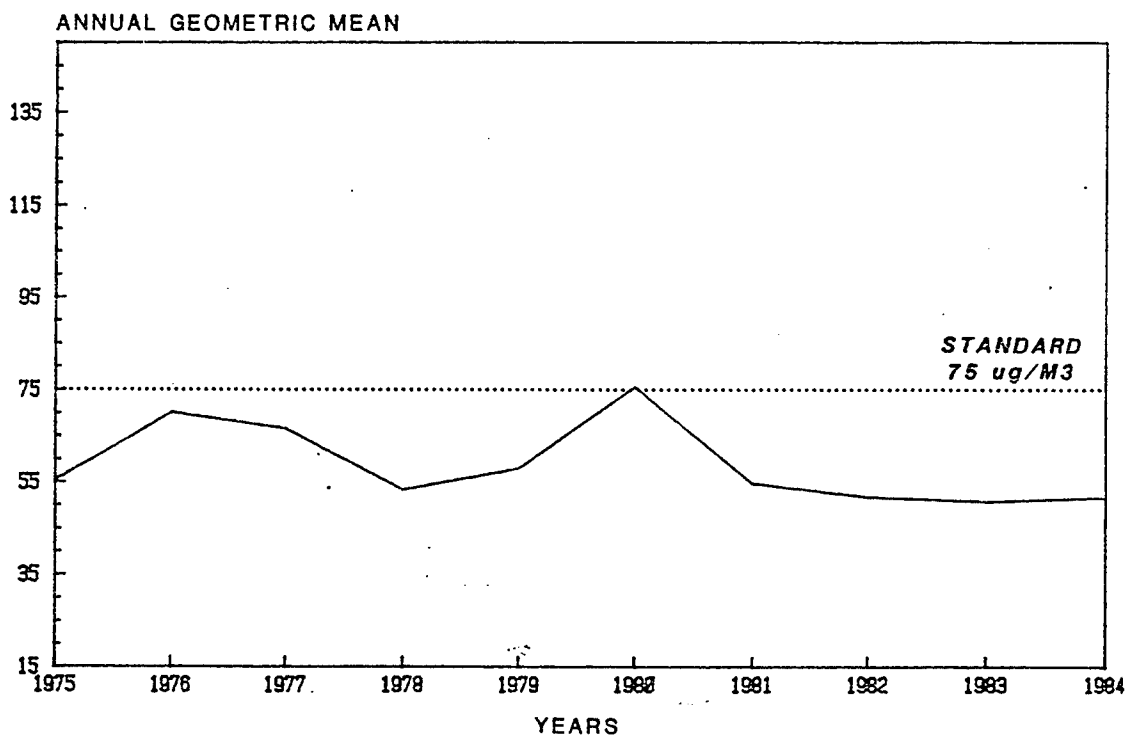


FIGURE 5-1

TOTAL SUSPENDED PARTICULATES
HISTORICAL COMPARISONS

AQCR #8

ALAMOSA
Science Bldg.



AQCR #9

DURANGO
10th & 2nd Ave.

PAGOSA
SPRINGS
High School

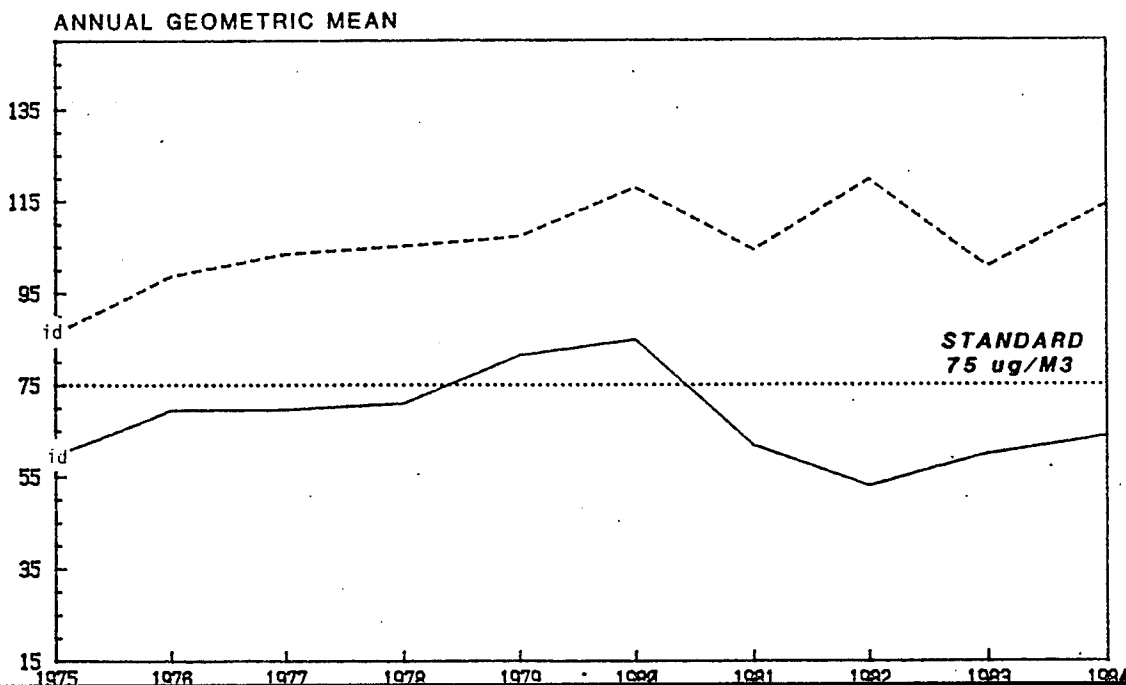


FIGURE 6-1

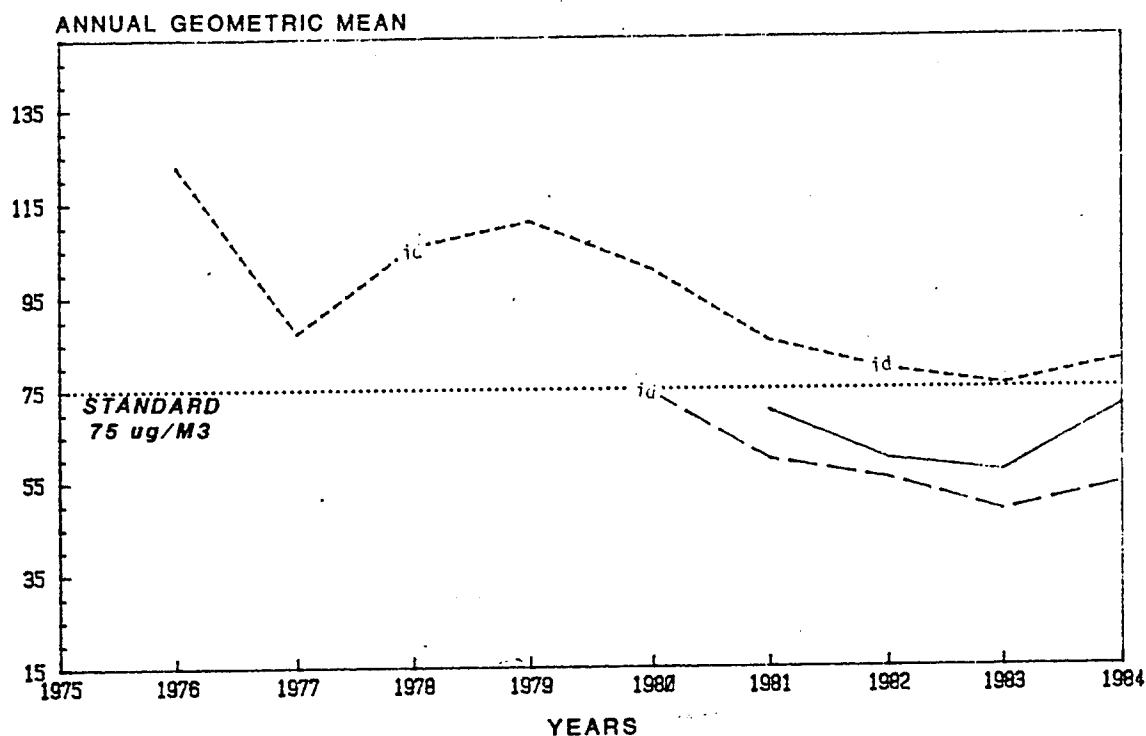
TOTAL SUSPENDED PARTICULATES
HISTORICAL COMPARISONS

AQCR #10

DELTA
5th & Palmer

MONTROSE
441 S. Uncompaghre

TELLURIDE
231 W. Colorado



AQCR #11

GLENWOOD SPRINGS
8th & Colorado

CRAIG
Courthouse

RANGELY
234 Jones Ave.

MEEKER
Courthouse

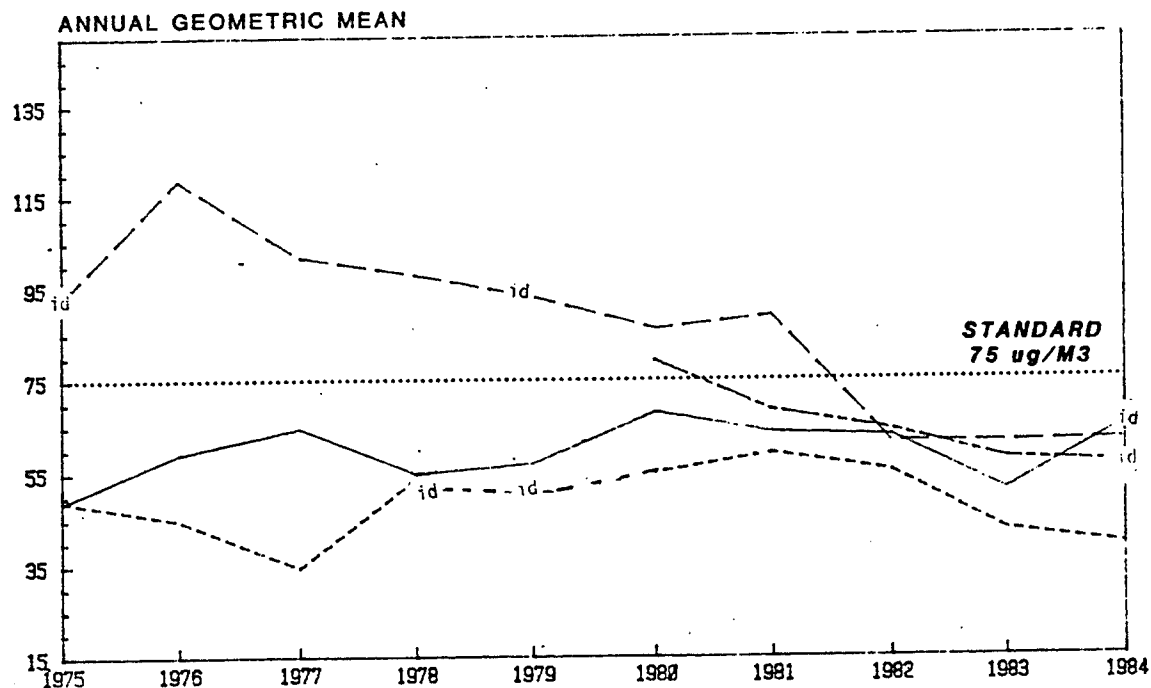
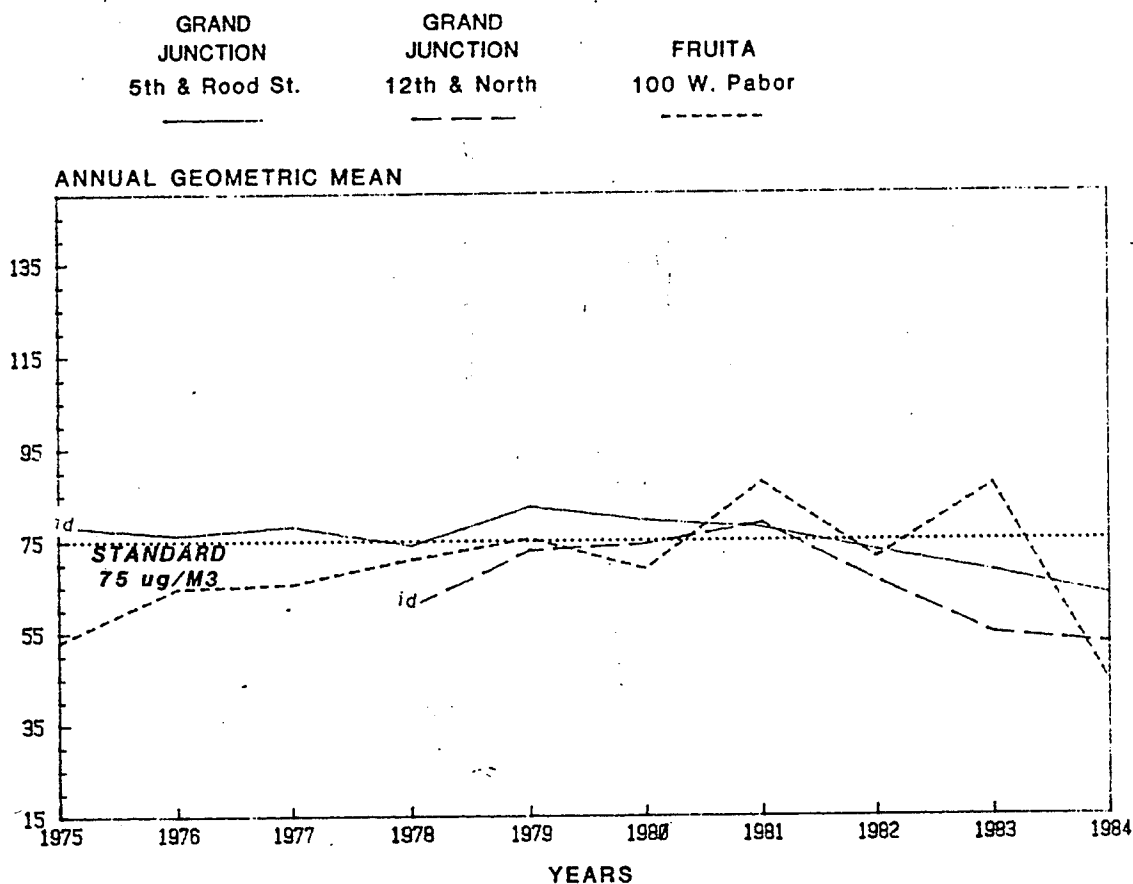


FIGURE 5-1

TOTAL SUSPENDED PARTICULATES
HISTORICAL COMPARISONS

AQCR #11



AQCR #11

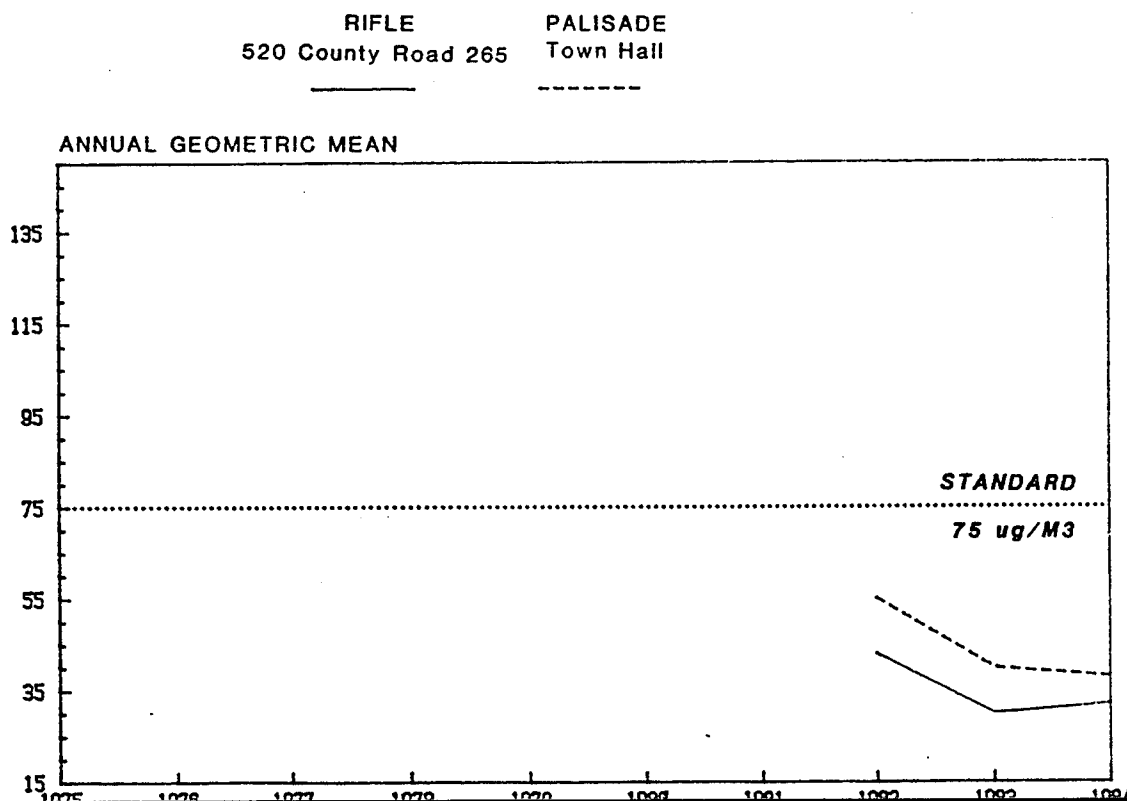


FIGURE 6-1

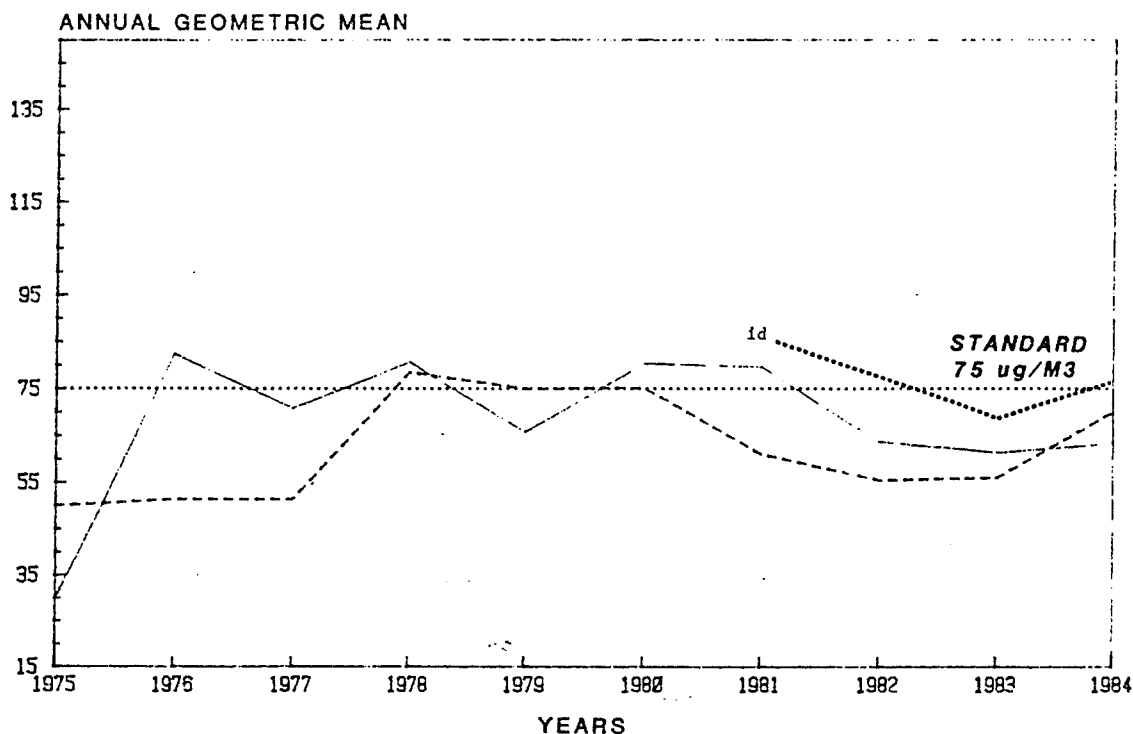
TOTAL SUSPENDED PARTICULATES
HISTORICAL COMPARISONS

AQCR #12

ASPEN
Courthouse

VAIL
Medical Bldg.

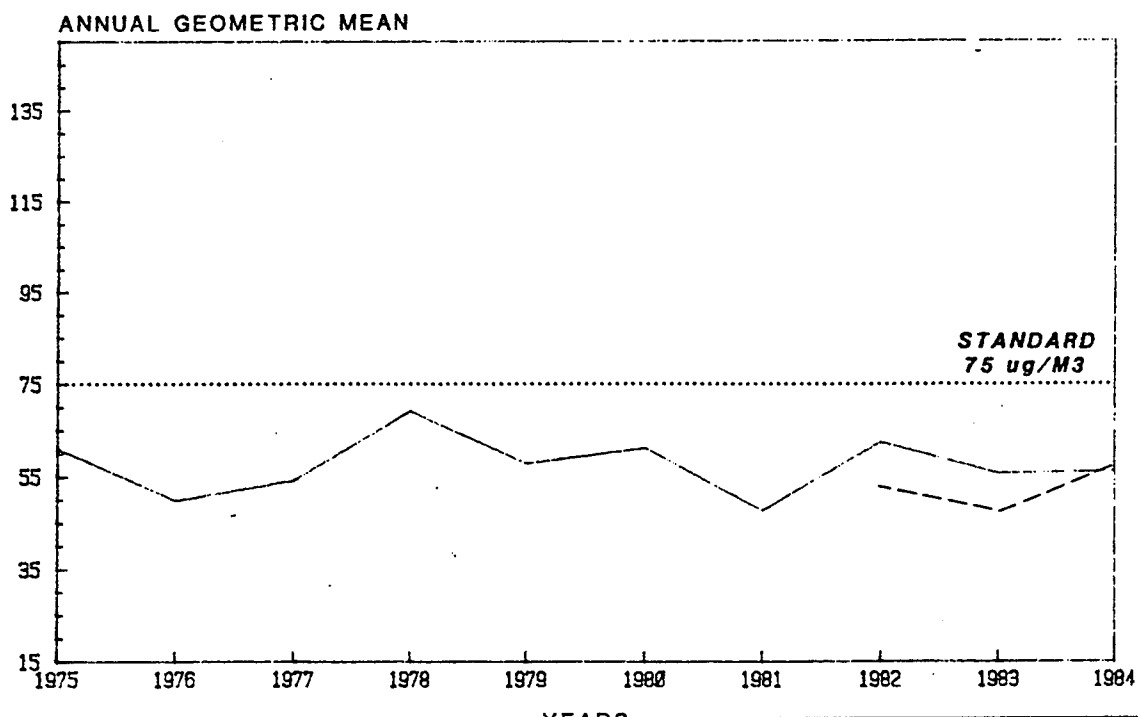
STEAMBOAT SPRINGS
929 Lincon



AQCR #13

CANON CITY
Macon & 7th

LEADVILLE
510 Harrison



7. LEAD (Pb)

7.1 Description and Sources

Lead in the ambient air exists primarily as particulate matter in the inhalable size range. The predominant source of atmospheric lead is from motor vehicles that burn "leaded" gasoline. The lead in gasoline is in the form of tetraethyl lead, an "anti-knock" compound. Another major source of atmospheric lead is the extraction and processing of metallic ores.¹⁷

7.2 Health Effects

When particles containing lead are inhaled, they are surrounded by mucous in the lungs. Eventually when the mucous is swallowed, lead finds its way into the blood stream through absorption in the gastro-intestinal tract. It is hypothesized that a very small portion is passed directly from the respiratory system into the body. Lead accumulation in the body can impair the production of hemoglobin.¹⁷ Clinical lead poisoning occurs when the body's accumulation of lead becomes too high. Symptoms of lead poisoning are intestinal cramps, peripheral nerve paralysis, anemia, and severe fatigue. Very severe exposure results in encephalitis and is frequently fatal. Lead concentrations in the ambient air, however, are not sufficient to produce lead poisoning. In fact, lead in the air contributes less than 30% to total body exposure.¹⁷ Table 7-1 contains a list of various health effects expected at different exposure levels. Due to the complex relationship between ambient lead concentrations and blood lead levels, Table 7-1 will relate effects observed with specific blood lead levels rather than ambient concentrations. The national strategy for controlling lead is to decrease the lead content in gasoline. This, coupled with the use of automobiles which require unleaded fuel to protect the catalytic converters, should continue to decrease ambient lead levels. It is interesting to note that, the U.S. population's blood lead levels declined 36.7% from 1976 to 1980.¹⁸

7.3 Standards

The current standard for lead is a 3-month (calendar quarter) average concentration not to exceed 1.5 micrograms of lead per cubic meter of air.¹⁹ This standard was established to maintain blood lead levels below 30 micrograms per deciliter of blood due to exposure to atmospheric lead concentrations.

7.4 Monitoring

Lead was monitored at 12 sites by the State in 1984 (see Table 1-2) by taking samples from the Hi-Vol filters from those sites and analyzing the samples for lead content, using an atomic absorption Spectrophotometer.

Table 6-1 contains the 1984 Data Summary for Lead. Figure 7-1 presents the lead Historical Comparison graphs.

TABLE 7-1

ESTIMATED HEALTH EFFECTS LEVELS FOR LEAD EXPOSURE¹⁷

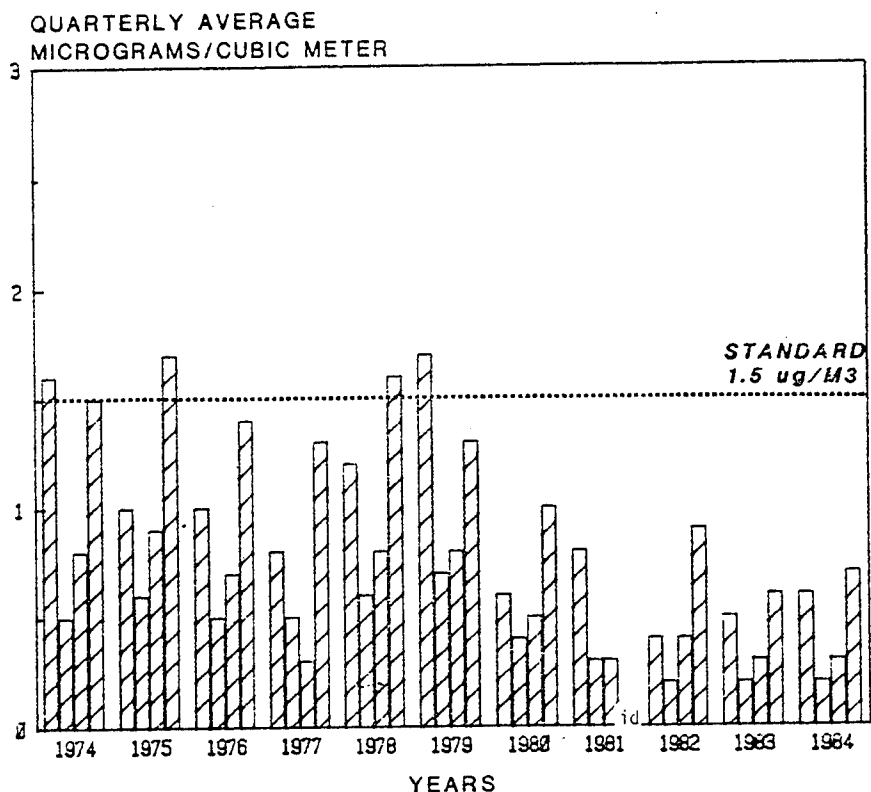
EFFECTS	EXPOSURE DURATION
ALA-D (aminolevulinic acid dehydrase) inhibition, erythrocyte protoporphyrin elevation.	10-30 Micrograms Lead per deciliter of blood (less than 1.5 microgram per cubic meter of air exposure over 3 months estimated.)
Increased urinary ALA (aminolevulinic acid) excretion, anemia, coproporphyrin elevation.	40-50 micrograms lead per deciliter of blood (greater than 1.5 micrograms per cubic meter of air)

FIGURE 7-1

LEAD
HISTORICAL COMPARISONS

AQCR #3

ADAMS CITY, 4301 E. 72nd Ave.



AQCR #3

DENVER, 414 14th Ave.

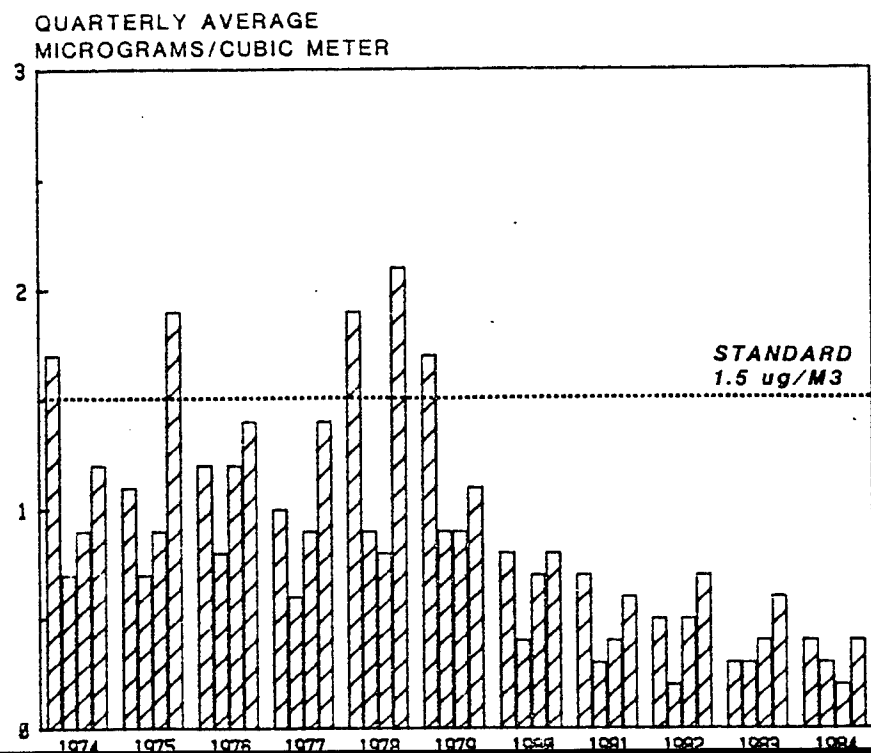
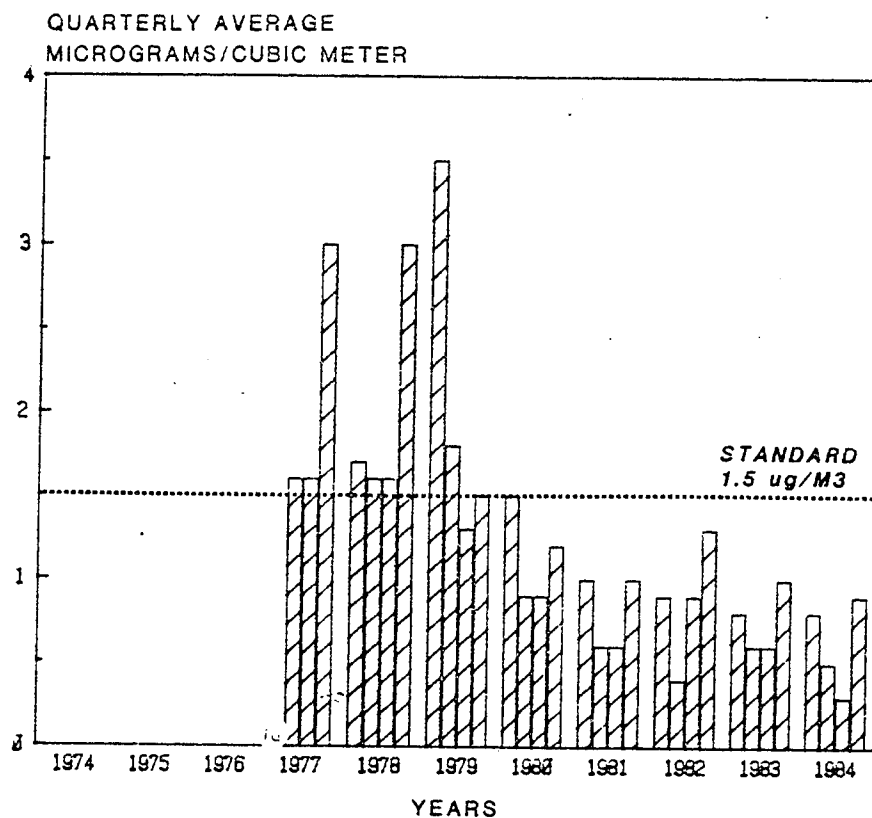


FIGURE 7-1

LEAD
HISTORICAL COMPARISONS

AQCR #3

DENVER, CAMP, 2105 BROADWAY



AQCR #3

DENVER, GATES, 1050 S. BROADWAY

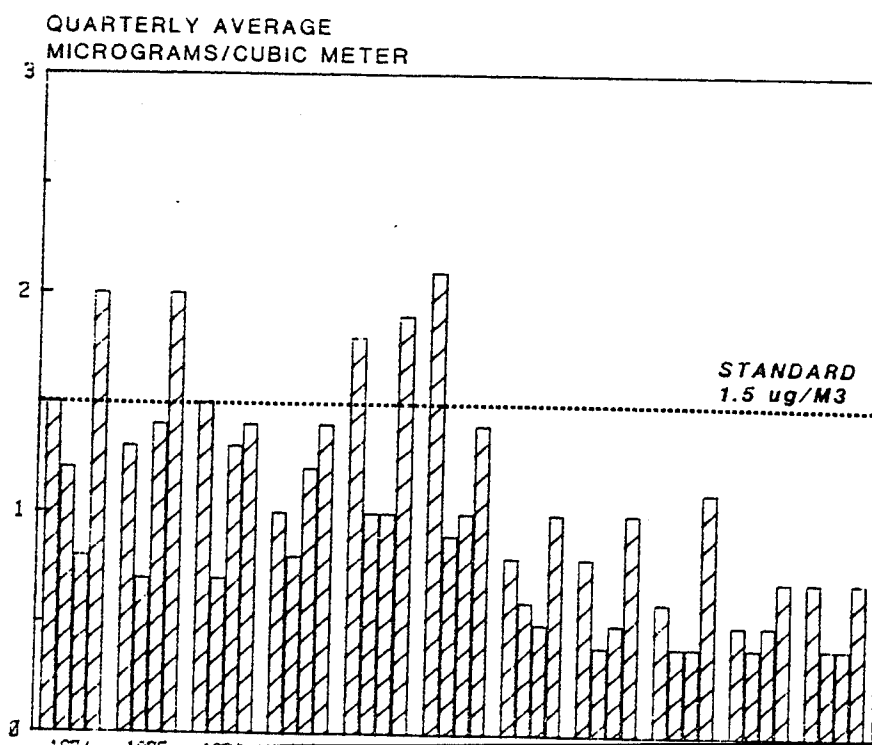
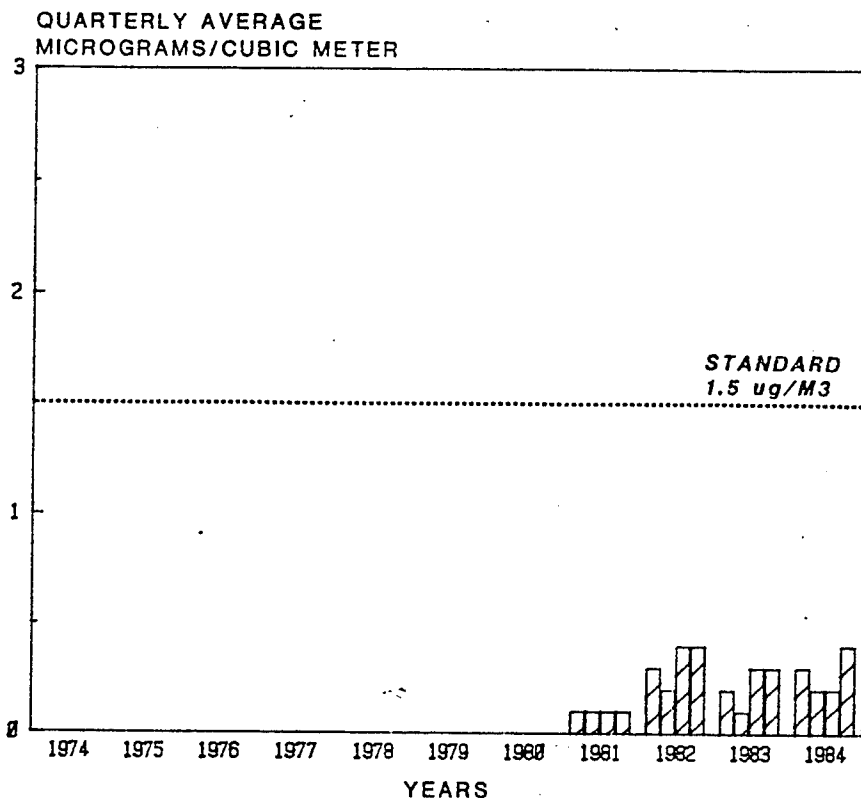


FIGURE 7-1

LEAD
HISTORICAL COMPARISON

AQCR #4

COLORADO SPRINGS, 501 N. FOOTE



AQCR #7

PUEBLO, 151 CENTRAL MAIN

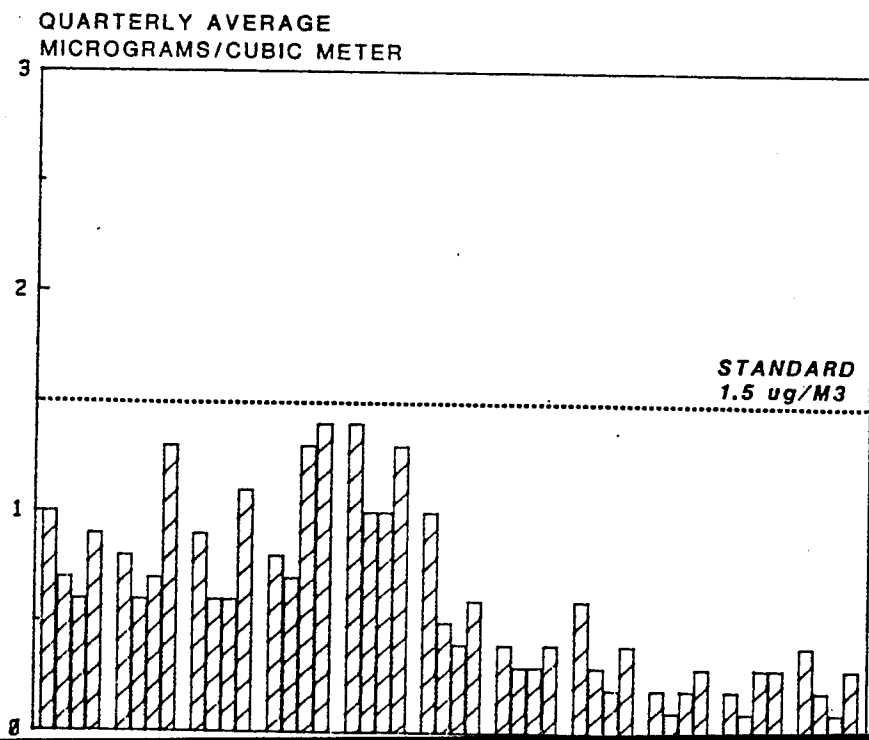
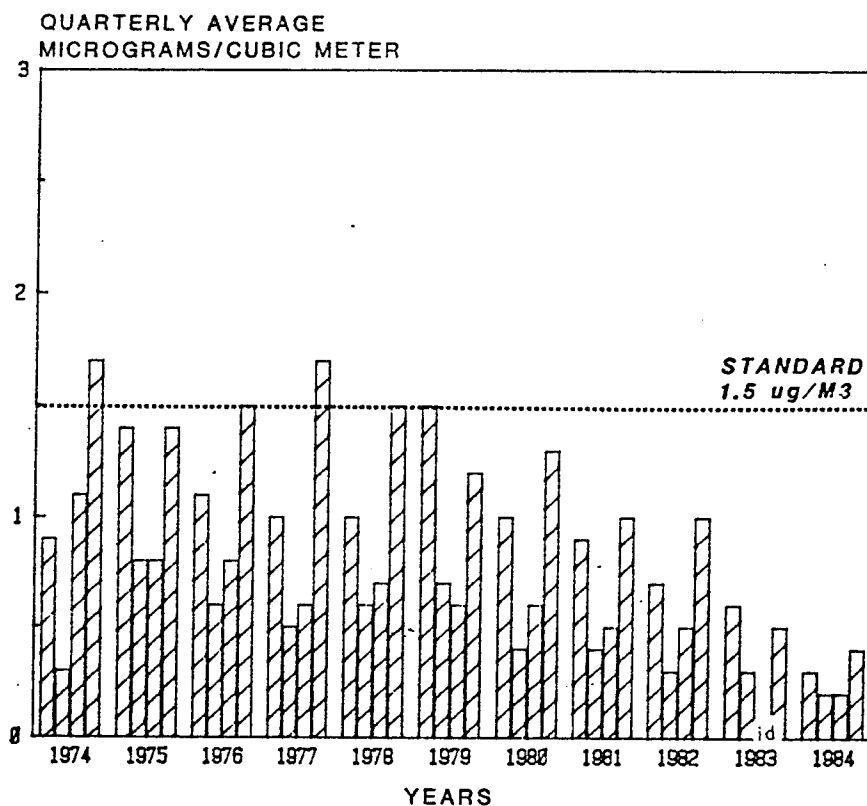


FIGURE 7-1 (continued)

LEAD
HISTORICAL COMPARISONS

AQCR #11
GRAND JUNCTION, 5th & ROOD St.



8. SULFATES ($\text{SO}_4^{=}$)

8.1 Description and Sources

The term "sulfate" is a catch-all term that relates to a class of chemical compounds that contain the functional sulfate ($\text{SO}_4^{=}$) ion. Sulfate compounds vary due to the mechanism that causes their formation. The most common method of detection also detects gas phase sulfuric acid. Other detected sulfates are ammonium sulfate, iron sulfate, and manganese sulfate to name a few.

As was discussed in Chapter 5, a portion of the sulfur dioxide emitted into the atmosphere produces particulate sulfates. The amount of sulfate formed is dependent on a number of factors including humidity, rain, sunlight intensity and the presence and concentration of other atmospheric pollutants.

Natural sources include volcanic eruptions. Non-sulfur-dioxide sources include sulfate fertilizers and direct emission of sulfates in plumes from specific sulfur-related manufacturing processes.

8.2 Health and Welfare Effects

Sulfate health impacts must be generalized because different sulfate compounds can cause different effects in the human biological system. Most human exposure studies have used various forms of sulfate aerosols when attempting to determine SO_2 and particulate impacts. For this reason somewhat better data exists for approximating health related responses to sulfate aerosols.

The welfare effects of sulfate exposure have been discussed in the sulfur dioxide section. They range from acid rain impacts to being a major component in rural and urban visibility problems. Acid deposition is related to widespread materials damage as well as crop and other vegetation damage. It should be noted that some evidence exists that supports the theory that limited amounts of sulfate exposure is actually beneficial to some agricultural crops in alkaline soil areas.²¹

No standards have been promulgated specifically for sulfates. However sulfates are controlled to some degree under the sulfur dioxide and particulate matter standards.

8.3 Monitoring

Monitoring for sulfates is accomplished by extracting the water soluble fraction from the total suspended particulate sample collected in the Hi-Volume sampler. The analysis is performed by use of a colorimetric method. Sulfate analyses were performed on TSP samples from 11 sites in Colorado in 1984. Table 6-1 summarizes 1984 data for sulfates.

Table 8-1 lists the indicated health effects at various exposure levels.

TABLE 8-1

ESTIMATED HEALTH EFFECTS LEVELS FOR SULFATE EXPOSURE²⁰

EFFECTS	EXPOSURE DURATION
Aggravation of respiratory symptoms in elderly and asthmatics.	8-10 micrograms per cubic meter of air in 24 hours.
Decreased lung function in children, increased acute lower respiratory disease, prevalence of chronic bronchitis, and acute respiratory disease.	11-15 micrograms per cubic meter of air, annual average.

9. NITRATES (NO_3^-)

9.1 Description and Sources

Atmospheric nitrates originate primarily from the transformation of gaseous oxides of nitrogen by chemical processes to produce a variety of nitrate compounds. Like sulfates, the term nitrate indicates a class of compounds that contain the functional nitrate (NO_3^-) ion. Both direct chemical transformation and more complex photochemical conversion take place at various rates depending upon atmospheric conditions and the presence of other pollutants. (See Figure 3-1). The direct emission of nitrate materials is also experienced on a limited scale both from industrial sources as well as from the application of nitrate fertilizers in rural areas.

One compound that can either be an intermediate or end product is nitric acid. Both the nitrate compounds and nitric acid are contained in either fine solid particles or appear as an aerosol droplet that for all practical purposes could be considered as a particle.

One class of end product nitrates, that has no parallel in the sulfate class, are the organic nitrates. The most common of these is peroxyacetylnitrate (PAN) which is associated in photochemical smog areas as the tear producing or eye irritant chemical.⁸

9.2 Health and Welfare Effects

The characterization of the health effects of nitrates has not been as well documented as for atmospheric sulfates. At elevated nitrate levels, increased symptoms and numbers of attacks in asthmatics have been observed. Table 9-1 presents the currently recognized concentration at which symptoms can occur based on the compilation of the results of 7 major studies in different areas of the country.

Welfare impacts are closely associated with problems of acid rain. Because one of the intermediate or end products of the nitrogen oxide conversion to nitrate is gaseous nitric acid, the potential impact to vegetation and other materials is widespread. A great deal of national concern over this problem has prompted considerable research into acid rain impacts.

9.3 Monitoring

Monitoring for nitrates, like sulfates, is accomplished by extracting the water soluble fraction of the total suspended particulate sample and analyzing using a colorimetric procedure. Some concern has been raised over the method of collection in high gaseous nitrogen oxide areas especially where elevated humidity occurs. The method of collection can actually generate nitrates on the filter collection material and produce false high readings. Due to the normally dry climate and relatively moderate nitrogen oxide levels in Colorado, this has not been a great concern.

Other techniques of collection are employed by a network of 6 acid deposition stations in Colorado but do not produce results dissimilar from those observed in the State's monitoring network.²²

Nitrate analyses were performed on TSP samples from 11 sites in Colorado in 1984. Table 6-1 summarizes 1984 nitrate data.

TABLE 9-1

NITRATES HEALTH EFFECTS⁸

<u>CONCENTRATION</u>	<u>EFFECT</u>
8 ug/m ³	40% increase in asthma attack rate when temperature exceeds 50°F over that expected when nitrates are less than 2 ug/m ³ .
1 ppm	PAN concentration - eye irritation

10. NITRIC OXIDE (NO)

10.1 Description and Sources

Nitric oxide is the most abundant (90%) of the oxides of nitrogen emitted from the sources discussed in Chapter 4 (NO₂). NO has no demonstrated adverse health effects at normal ambient concentrations. However, NO is the precursor to atmospheric formation of nitrogen dioxide, nitric acid, and nitrates, all of which do have demonstrated adverse health effects, and also contribute to acid deposition problems. Nitrogen oxides are also a precursor in photochemical formation of ozone. Figure 3-1 visually presents the complex interrelationships among NO, NO₂, O₃, and nitrates on a typical photochemically productive day.

10.2 Monitoring

NO is monitored using the same chemiluminescence monitors utilized for nitrogen dioxide monitoring. The analyzer actually establishes ambient levels of nitrogen dioxide by determining the difference between total oxides of nitrogen and NO concentrations. Table 11-1 summarizes the 1984 NO data.

TABLE 10-1

NITRIC OXIDE (NO)

1984 DATA SUMMARY
(parts per million)

<u>SITE</u>	<u>LOCATION</u>	<u>DAYS MONITORED</u>	<u>ANNUAL AVERAGE</u>
3-Y	Aurora, 50 So. Peoria	362	0.01
3-J	Denver (CAMP), Broadway & 21st	355	0.06
3-W	Welby, 78th And Steele	327	0.03
4-A	Colorado Springs, 712 S. Tejon	339	0.04

11. TOTAL HYDROCARBONS (THC), METHANE (CH₄) and NON-METHANE HYDROCARBONS (NMHC)

11.1 Description and Sources

A vast variety of hydrocarbon compounds are emitted from automobiles, solvent and fuel production, distribution, and storage, refining, painting, dry cleaning, etc. Natural sources, such as plants, also emit hydrocarbons. Localized anthropogenic (man made) emissions of hydrocarbons can outweigh the contribution from natural sources, although on a global basis natural sources are largest.²⁹ The primary concern over hydrocarbons in the atmosphere stems from their involvement in the photochemical production of ozone. Certain hydrocarbons, nitrogen oxides and sunlight produce ozone as one byproduct which is related to adverse health impacts. (See Figure 3-1). The simplest of the hydrocarbons, methane (CH₄), is considered to be photochemically non-reactive in urban atmospheres. Methane is monitored simultaneously with total hydrocarbons so it can be subtracted from total hydrocarbons to provide a measure of non-methane hydrocarbons (NMHC). Other hydrocarbons not directly related to photochemical processes may be of concern for various health and welfare reasons.

11.2 Health and Welfare Effects

During the deliberation process which led to the formation of an ambient hydrocarbon standard in 1971, EPA stated, "the only direct effect attributed to ambient levels of hydrocarbons is the vegetation damage from ethylene."²⁵ This effect is well documented in areas where high levels of ethylene are present. Injury to sensitive plants from ethylene occurs from 0.1ppm to .5 ppm over an 8-24 hour period.²⁴ Other organic vapors (aldehydes) also have documented impacts on vegetation.²⁴ Health effects, however, are less defined. A review of the NAAQS for hydrocarbons concluded in 1981 that,

"there was no demonstration of any direct health effects of the gaseous hydrocarbons in the ambient air on people although many of the effects attributed to photochemical smog were indirectly related to ambient levels of these hydrocarbons."²⁶

11.3 Standards

In 1971, EPA promulgated an ambient air quality standard for non-methane hydrocarbons. At that time it was stated that: "The sole purpose of prescribing a hydrocarbon standard is to control oxidants".⁵ The standard was 0.24 ppm maximum 3-hour concentration from 6 to 9a.m. not to be exceeded more than once per year. The hydrocarbon standard was intended as a guideline for determining the hydrocarbon emission reduction necessary for attaining the ozone standard. However, more sophisticated analysis techniques (i.e., photochemical modeling) soon became available to relate ozone concentration reductions to hydrocarbon emission reductions, and therefore the hydrocarbon standard became obsolete by the mid 1970's though it remained on the books. On January 5, 1983, the standard was repealed due to EPA's finding that the standard was technically inadequate.²⁷ It was concluded that hydrocarbons as a class did not appear to cause adverse health or welfare effects at present

ambient levels. However, specific hydrocarbons which are shown to cause adverse effects can be regulated separately in the future. One of the specific concerns is benzene which has been under study as a hazardous pollutant. An organic chemical presently regulated in Colorado is vinyl chloride for which an emission standard of 10 ppm exists.

11.4 Monitoring

In 1984, monitoring for methane and total hydrocarbons was performed at only one site, the CAMP station. Due to a long term data base and EPA's lack of a standard methodology, this monitoring was discontinued in July of 1984. The mean value listed in Table 12-1 represents only a half years data in 1984. The methodology is a flame ionization technique where two identical analyzers continuously monitor the atmosphere. One analyzer is equipped with a scrubber to allow only methane to pass through, thus allowing the measurement of total hydrocarbons and methane separately.

TABLE 11-1

TOTAL HYDROCARBONS AND METHANE

1984 DATA SUMMARY
(parts per million)

<u>SITE</u>	<u>LOCATION</u>	<u>ANNUAL MEAN THC</u>	<u>ANNUAL MEAN CH₄</u>
3-J	Denver (CAMP), 21st & Broadway	2.1	1.9

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